THE

ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

2031

VOLUME XXVIII

October, 1904, to March, 1905

NEW YORK

THE ENGINEERING MAGAZINE

1905

Copyright, 1904

By JOHN R. DUNLAP

THE ENGINEERING MAGAZINE

THE WORLD IS ITS FIELD

VOL. XXVIII. OCTOBER, 1904. No. 1.

THE ST. LOUIS EXPOSITION, FROM THE STANDPOINT OF THE ENGINEER.

By William H. Bryan.

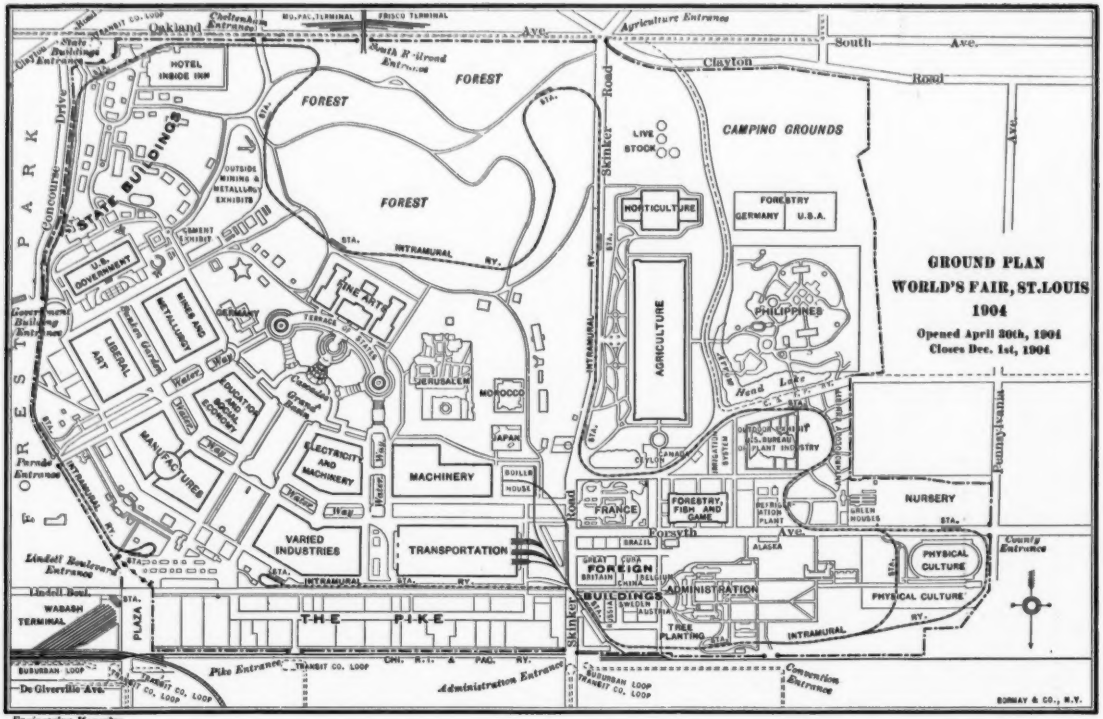
Mr. Bryan considers the St. Louis Exposition—what it is, and what it exhibits—as a current record and demonstration of engineering progress. It is most interesting to compare it from this point of view with the still recent Buffalo Exposition, which was reviewed in these pages in October, 1901, and to note the advance, especially in power generation and electric applications.—THE EDITORS.

"EXPOSITIONS are the time keepers of progress." Thus spoke President McKinley in his memorable address at the Buffalo exposition. Every engineer in touch with industrial development will bear eloquent testimony to this truth.

On April 30, 1803, a treaty was signed between France and the United States by which the latter acquired, for the consideration of $15,000,000, the territory west of the Mississippi River (then known as Louisiana) aggregating 1,171,931 square miles—an addition which more than doubled the national domain.

A popular movement looking to the celebration of the centennial of the event began in St. Louis in 1898. In January, 1899, a congress representing the fourteen States and territories which had been carved out of the Louisiana Purchase, met in St. Louis and formally launched the project of a universal exposition. It was early determined that the event justified a celebration which would excel all previous efforts. An executive and a general committee of two hundred citizens was formed, and Congress shortly afterward gave the enterprise formal approval. President McKinley then issued a proclamation inviting the participation of all nations. A special charter

Copyright, 1904, by John R. Dunlap.



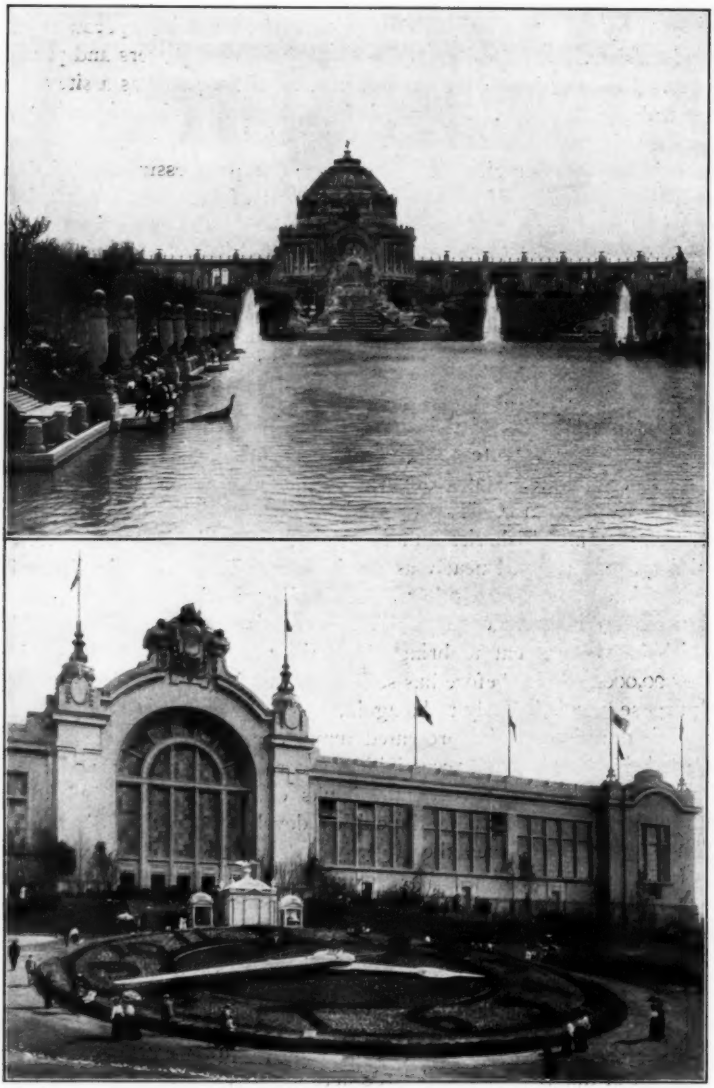
Engineering Magazine

GENERAL OUTLINE PLAN OF THE LOUISIANA PURCHASE EXPOSITION.

granted by the Missouri legislature authorized the incorporation of the Louisiana Purchase Exposition Co., with liberal powers and privileges. The selection of the old French city of St. Louis as a site was particularly fortunate. Not only is it the largest city in the territory, but there is said to be a larger population within a radius of 500 miles than in any similar circle in America. The progressiveness of the city, the hospitality of its people, the extent of its manufactures, its proximity to the great southern Illinois coal-fields, its importance as a railway center, and its location on the great Mississippi River, near the mouths of the Missouri and Illinois, are all factors in its commercial importance.

Finances were, of course, of first importance, and stock subscriptions were invited, resulting in the underwriting of the entire amount, $5,000,000, payable in installments. These came from railroads, business houses, hotels, and public-spirited citizens of high and low degree. By popular vote the city of St. Louis issued $5,000,000 in bonds. The United States Government gave $5,000,000, adding later a loan of $4,600,000. The cost of its own exhibits, including the Government and Fisheries buildings, and the Philippines, life-savers, soldiery, etc., reached nearly as much more. The State of Missouri appropriated $1,000,000, other States and territories $6,000,000, foreign Governments $5,000,000. A conservative estimate of the total which has been spent to bring about the present splendid result is $50,000,000. Never before has so large a sum been available for such a purpose, nor is it likely to be again.

The question of site presented many complications, the requirements being ample area, accessibility, favorable topography, and reasonable cost. Many favored the banks of the historic Mississippi River, but insurmountable difficulties developed in that direction. The solution came when the city of St. Louis tendered the western half of Forest Park, then an unimproved wilderness of rolling topography, covered mostly by a dense forest of old oak trees. The eastern and improved section of this park is one of the city's most popular outing grounds. The distance from the heart of the city to the Fair's eastern boundary line is 5½ miles. Although the 700 acres thus secured exceeded the area of any previous exposition, it was deemed insufficient, and extensive tracts to the north and west were leased. Included in this territory is the 100-acre campus of Washington University, and its six new permanent granite buildings. These leases extended the western boundary a considerable distance beyond the western city limits, and completed the Exposition territory (page 2)



THE CASCADES, FROM THE GRAND BASIN, SOMETIMES CALLED THE "MAIN PICTURE" OF THE EXPOSITION, AND THE FLORAL CLOCK IN FRONT OF THE PALACE OF AGRICULTURE.

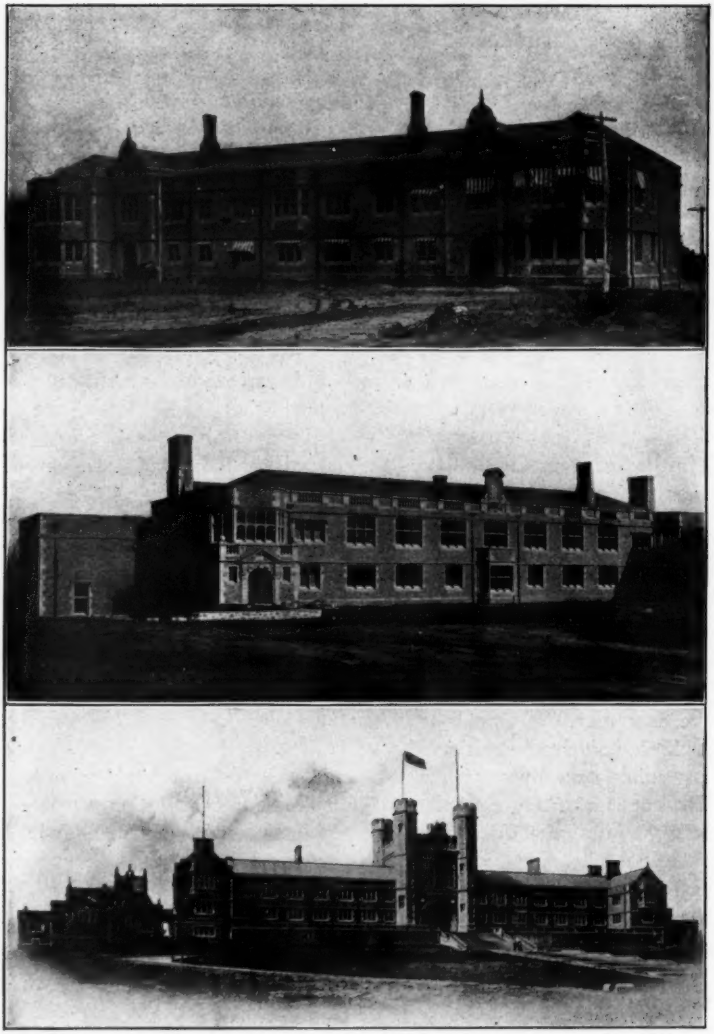
Copyright, 1904, by The Louisiana Purchase Exposition Co.

which is now approximately two miles long east-and-west by one mile wide, and aggregates 1,240 acres, double the area devoted to the largest previous exposition, the Columbian.

The Exposition authorities seem, however, to have over-estimated their requirements, for it has been found impossible to utilize to advantage this vast area. Ample grounds permitted buildings of great area, extensive waterways, opportunities for landscape gardening, and agricultural, horticultural, and forestry exhibits; splendid avenues, vistas, and plazas; and room for immense special exhibits. But it involved serious problems of inter-communication, roadways, preparation and care of grounds, water service, drainage, and has led to great discomfort to the visitor in attempting to cover such long distances. Much of the enclosure is unimproved and practically unoccupied; parts are wholly neglected, and others used for storage of débris of every sort, detracting not a little from the finished picture. The general effect would have been better if the work had been concentrated within, say, two-thirds the present area.

Transportation to the grounds has been well worked out. Seven branches of the St. Louis Transit Company's lines, and three of the Suburban system—both surface electric—reach the grounds, covering the distance from the heart of the city in about 35 minutes. Shuttle trains run between the Union Station and the main entrance at 15-minute intervals, making the run in about 12 minutes. There is also an automobile service from down town. Inside the Exposition the Intramural, a double-track surface electric-trolley line, on the multiple-unit system, skirts the grounds. Its length of double track is 7 miles, and about 30 minutes are required for the trip one way. The cars unfortunately are not well suited for observation purposes, being the ordinary closed box type with end entrances. The standard open car with side entrances would have been better. Automobiles traverse the principal avenues, and there are roller chairs, jinrickshas, and a miniature railway. These, with the launches, afford ample means for getting about.

At an early day a number of standing committees were appointed, each to look after a particular part of the work. A commission of ten leading architects was selected to prepare a general scheme of grounds and buildings. Five of these were from St. Louis, and five from other important cities, one of the latter, however, declining the appointment. This commission made a study of the topography of the site, and decided upon a general scheme for the main building, waterways, etc., mapping out what has since been so successfully executed as the "Main Picture."



PERMANENT BUILDINGS OF THE LOUISIANA PURCHASE EXPOSITION.

Forming part of the Washington University group. At the bottom is the Administration Building, being Brooking's Hall of the permanent University structures. Next above is the Anthropology Building—Cupples Hall No. 1 of the University, to be devoted to civil engineering and architecture. At the top is another of the Administration buildings—Cupples Hall No. 2, of the University group, to be used by the departments of mechanical and electrical engineering.

Unfortunately, the original scope of the commission of architects was not adhered to, the chairman personally assuming the supervision and control of all work, the commission itself never being called together after the first few meetings. This chairman, a man of much force of character and executive ability, overloaded himself in assuming the responsibility not only for the general architectural effect, but for all structural details—including engineering work—with results that from some standpoints are regrettable. Some of these would undoubtedly have been avoided had the ability and services of the original commission been retained. As the architectural features have already been amply discussed by competent critics, only two will be mentioned here. The first is the absence of monumental architectural closures at the outer ends of the three main courts. There is no effective ending to the view, the composition being left unfinished. The second is the absence of anything approaching the monumental—or even the dignified—at the main approaches or entrances.

The preparation of the grounds involved some difficult engineering. Through the site wandered the erratic River Des Pères, ordinarily harmless, but frequently overflowing its banks after severe rain storms. This stream had to be regulated, and its flow area enlarged. It has been enclosed in a wooden box, wholly concealed, its top covered with an asphalt roadway, now forming one of the main avenues. The irregularities of the site called for enormous amounts of grading and of pile driving to support some of the main buildings and machinery. A considerable portion of the area now occupied by the main picture was a deep forest, which formed one of its most picturesque attractions. The trees were felled with a ruthless hand, a step which brought so forcible a protest from the public as to cause a radical change in practice, too late, however, to save the best of them.

Not the least of the problems was the construction of roadways, for both the construction and Exposition periods. For the main thoroughfares asphaltum was employed, and brick on those of less importance. These have proven satisfactory, but the macadam and burnt clay used for the extensive system of ordinary roadways have given results less pleasing, being always in bad condition after heavy rains.

The drainage has been handled satisfactorily, the storm water going to the Des Pères, and the sewage proper by gravity to receiving tanks near the north corner of the Mines and Metallurgy Building, from which electric pumps lift it twenty feet and discharge it north to one of the main city sewers.

Water is supplied directly from the city system, at a special rate of one per cent. per 1,000 gallons. Individual filters for special uses are

located at various points, one plant supplying the water to make up the leakage and evaporation from the lagoons. For ordinary use the supply is under city pressure, but the reserve in Arrowhead Lake is available for fire service. An independent system for fire protection has been laid, on which 150-pounds pressure is maintained by fourteen underwriters fire pumps of the horizontal duplex pattern, each automatically controlled. These are located in the northern portion of the Steam, Gas, and Fuels Building.

The design and grouping of the principal buildings in the "main picture" are extremely gratifying to the layman, although experts criticize some of the details. The interesting engineering feature is the extensive use of wood for the framing. Considerations of time and expense indicated originally that it would be inadvisable to use steel. Experts differ as to the wisdom of this conclusion, some holding that steel frame work could have been secured in ample time, and at but little if any greater cost. But three buildings, the United States and the Belgian National Pavilions, and the Steam, Gas, and Fuels Building, have steel frames. Everywhere else the construction is of wood, but on so gigantic a scale and involving such difficult problems as to excite wonder and admiration. The increased frequency of columns, however, the absence of spacious spans, the increased fire risk, and lack of rigidity, are distinct objections. In this respect the buildings are a disappointment—a step backward as compared with previous expositions. All the exhibits are on the ground floors, the small galleries being occupied only by department administration offices. The total area under roof is 250 acres.

The buildings outside the main picture are of almost equal interest, particularly the Palace of Agriculture (page 4) to the west, said to be the largest ever constructed for a single department. There are also the six original Washington University buildings (page 6) magnificent permanent granite structures, Tudor-Gothic in architecture. To these the Exposition has added, as part rental, five similar in character, forming the permanent Washington University group, in which that energetic institution expects to begin its new life immediately after the Fair.

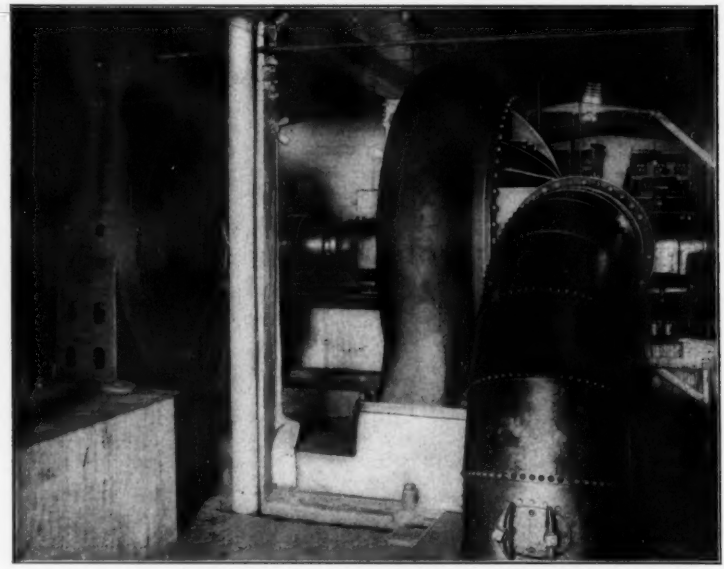
The State and national pavilions are, as a rule, successful structures. Many of them are copies of buildings famous in story and song. Very beautiful are those in the southwestern section of the grounds. Many resemble old country homes, and are surrounded by spacious grounds, winding roadways, stately forest trees, and splendid lawns and gardens.

FESTIVAL HALL, WITH THE CASCADES IN OPERATION.

Copyright, 1904, by the Louisiana Purchase Exposition Co.

The lagoons surround the Palaces of Electricity and Education, which latter are separated by the main basin. At the south end of the latter are the Cascades, undoubtedly one of the most charming features of the Fair. From each of the three pavilions on the ridge of Art Hill there pours a constant stream of water, the total fall

into the main basin being approximately 100 feet. The ledges form numerous falls, ripples, and basins—artificial, of course—but none the less realistic. Underneath the overhanging ledges are placed numberless colored incandescent lights. Along the sides of the cascades are groups of statuary, from which flow streams of water. In the main basin, near the foot of the falls, are three large fountains.

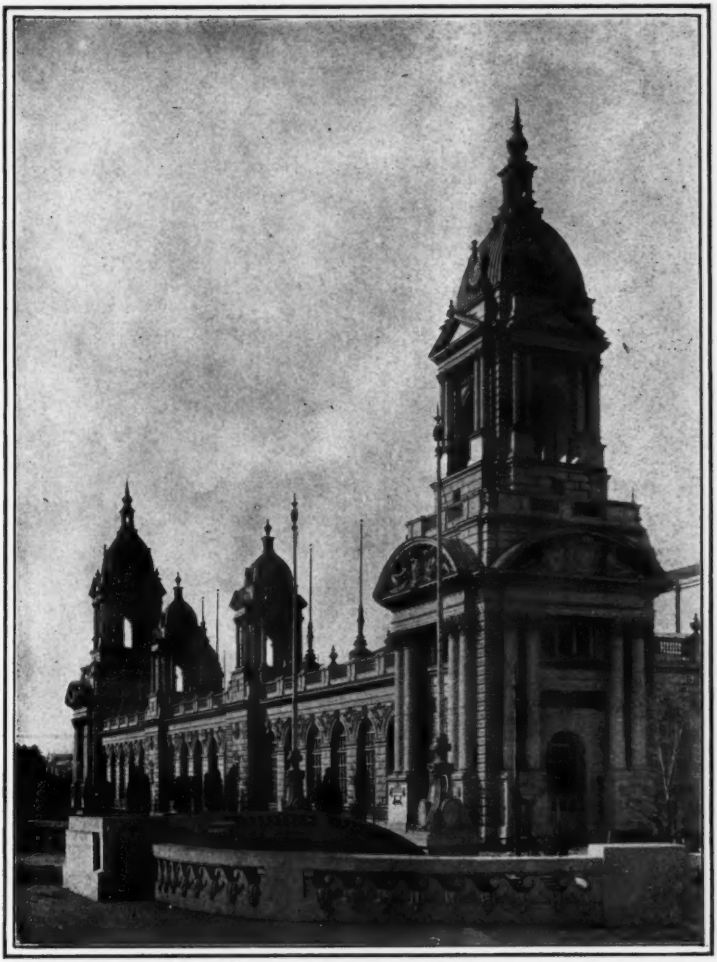


WORTHINGTON TURBINE PUMP DRIVEN BY INDUCTION MOTOR. ONE OF THE SET OF THREE SUPPLYING THE CASCADES.

The power plant controlling this splendid effect is located under the East Cascades. It consists of three Worthington turbine pumps, each of 35,000 gallons-per-minute capacity, working against 160-foot head. Each is direct driven by a 2,000-horse-power induction motor, at 365 revolutions. The plant was designed for a maximum flow of 100,000 gallons per minute, and ample power was provided for the purpose. Some doubt having arisen as to the strength of the cascade framework, however, but one pump is run at a time, and the effect —while impressive—is not altogether what had been anticipated. On the main basin electric and gasoline launches and Venetian gondolas ply, with vari-colored lights, adding greatly to the beauty.

Exceeding even the Cascades in beauty and grandeur is the electrical illumination which begins every day at dusk. Following the

successful Buffalo idea, the architectural outlines of the buildings in the main picture are studded with 8-candle-power incandescent lamps, some 140,000 being employed. Many of these are located behind columns and colonades, thus throwing the buildings themselves into relief (page 12). The effect is beautiful and enchanting beyond de-



THE PALACE OF MACHINERY.

Copyright, 1904, by the Louisiana Purchase Exposition Co.

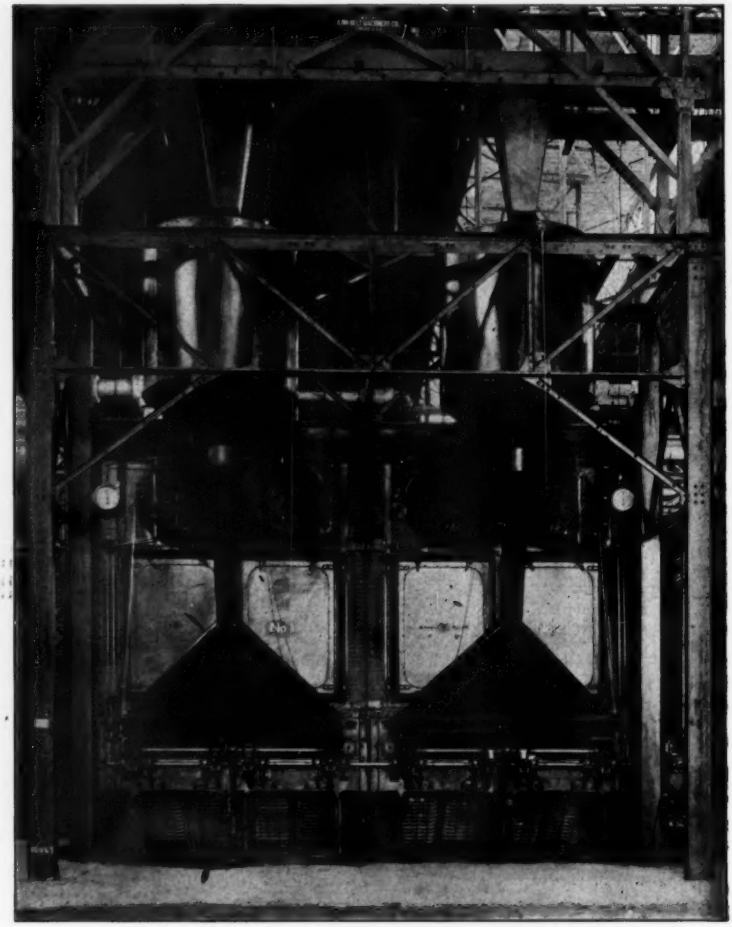
THE PALACE OF ELECTRICITY BY NIGHT.

scription. Festival Hall (shown on page 9), the central Pavilion on Art Hill, the Colonnade of States, and the outer pavilions, are so wired that the colors may be changed. The lamps are located in groups of three, red, white, and green, each color on an independent circuit. These colors are changed by means of switches every few minutes, with splendid effect. No more perfect picture can be imagined than is afforded by a night trip around the lagoons, the summer moon in the heavens, the water craft passing to and fro with gaily colored lanterns, the splendid illumination on every side, the brilliantly changing colors on Art Hill, the reflections in the water, all attuned to the deep undertone of the cascades. Certainly the popular verdict which long since selected this as the crowning feature of the Fair—exceeding indeed all previous Fairs—has not gone astray.

The service power plant of the Exposition, located in the west end of the Palace of Machinery, presents many interesting features, although it involves nothing particularly novel or striking. About one-third of the apparatus is leased, and two-thirds was installed by exhibitors. The boiler plant is located in the Steam, Gas, and Fuels Building, a plain structure, located just west of the Palace of Machinery. There are 52 independent boilers, all of standard horizontal and vertical water-tube types, aggregating about 20,000 rated horsepower (page 14). There are seven foreign boilers of the marine type, the Belleville, Dürr, Niclausse, and Schütte. All have induced draft, short steel stacks, and mechanical stokers or chain grates, except six of the smaller units. Neither economizers or superheaters are used, except in the case of the French boilers, which supply superheated steam to the French engine. The pressures carried are 175 for general use, 225 for the steam turbines, and 300 with 200 degrees superheat, for the French engine.

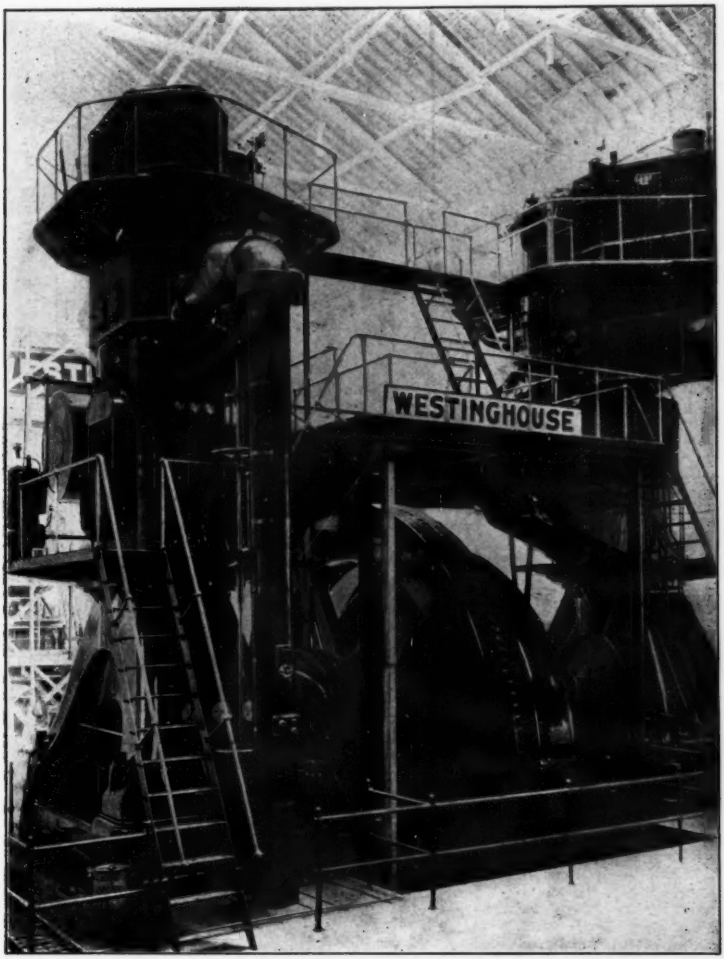
The Exposition owns its own system of coal cars, which are of the 50-ton hopper-bottom type, and can be dumped in 8 minutes. The coal is then conveyed to crushers and elevated to 500-ton bunkers, from which it is fed directly to the stokers. The ashes drop from chutes into metallic cars in tunnels, and are then conveyed and elevated into cars. About 70 per cent. of the boilers are required for the maximum load, and an average of 500 short tons of ordinary bituminous coal from Troy, Ill., is consumed per 24 hours. The smoke record is fair, although not as good as the present state of the art would lead one to expect. Many interesting details may be noted, such as the various types of feed pumps, heaters, purifiers, flue cleaners, etc. Lack of stability of the framework of the buildings made it necessary to support all the pipe work from below.

Space will not permit further details regarding the capacity, make, and type of the boiler units, nor for the engines and generators. These latter aggregate about 35,000 rated horse power, and represent good modern practice, and are interesting in many respects, although they represent nothing particularly remarkable. The engines are both vertical and horizontal, of the Corliss (pages 15 and 16) and



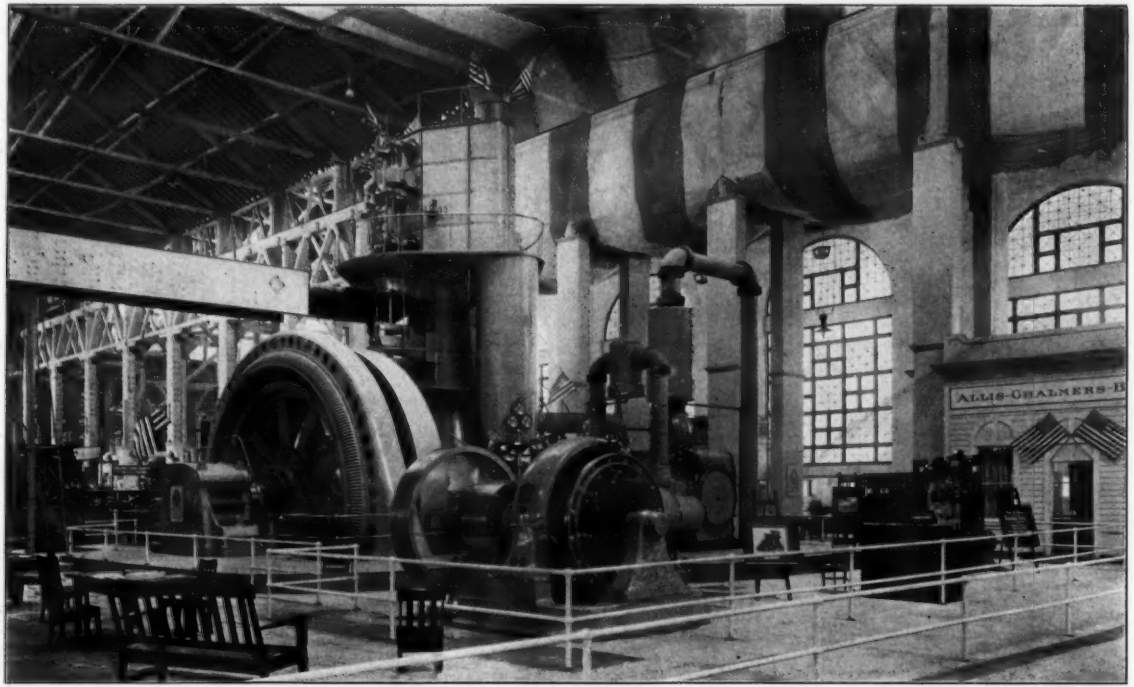
BOILER BATTERY, STEAM AND FUEL BUILDING.

Showing equipment with Roney mechanical stokers, receiving coal from overhead hoppers.



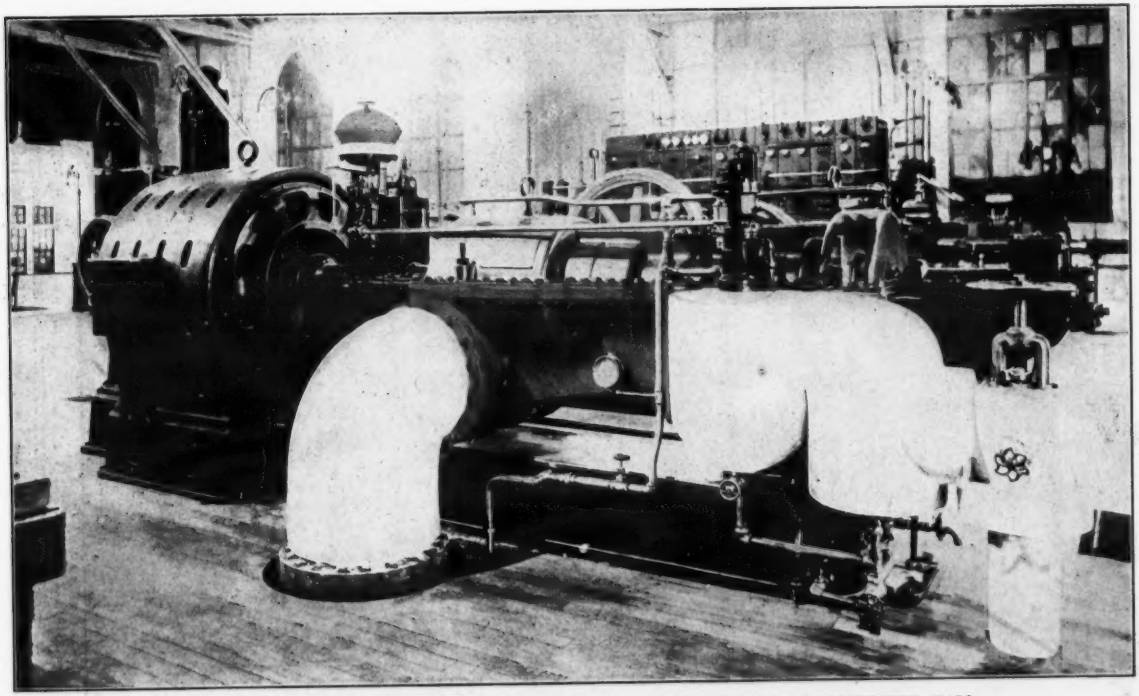
THE 3,500-HORSE-POWER WESTINGHOUSE CORLISS ENGINE, IN THE EXPOSITION SERVICE PLANT, MACHINERY HALL.

other well-known American types. All are compound condensing, except a Willans, and the DeLaunay-Belleville French steam engine, a six-cylinder quadruple-expansion, of the marine type, for 300-pounds initial pressure, with generator, exciter, condenser, circulator, and air pump, all on one base. All the prominent makes of steam

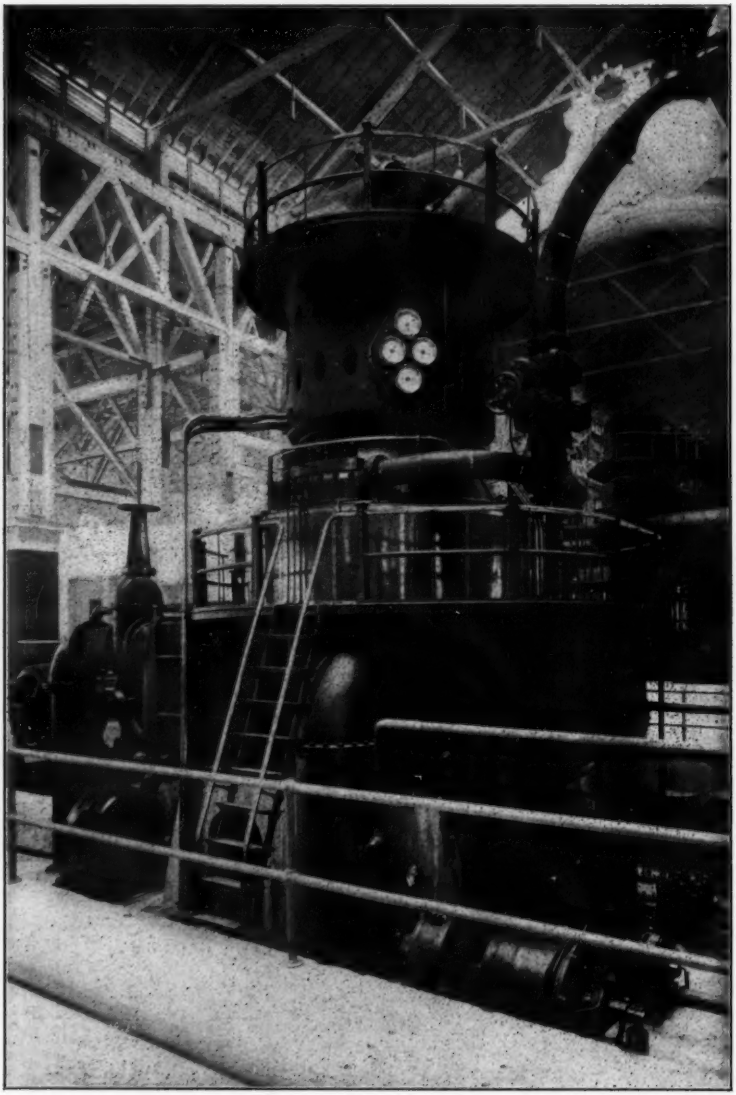


THE ALLIS-CHALMERS-BULLOCK POWER INSTALLATION WHICH FURNISHES CURRENT FOR DECORATIVE LIGHTING ON THE MAIN EXHIBIT PALACES.

A 5,000-horse-power engine and 3,500-kilowatt generator.



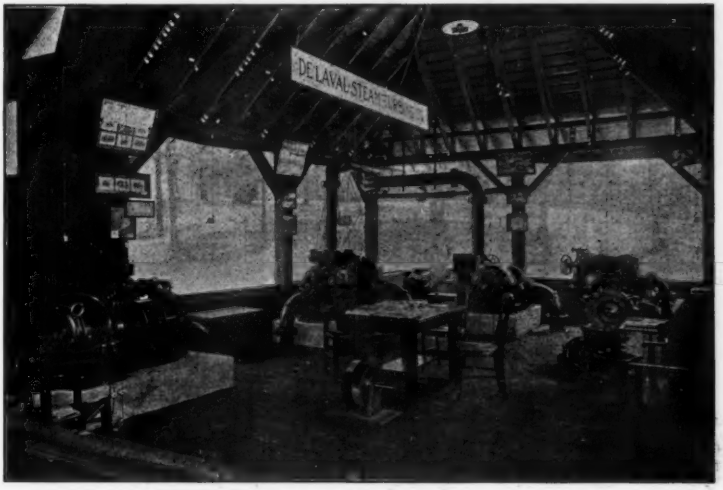
VIEW OF 600-HORSE-POWER WESTINGHOUSE-PARSONS STEAM TURBINE, IN MACHINERY HALL.
Photographed in operation, at 9.30 p. m., by the light of Cooper-Hewitt mercury-vapor lamps.



THE 3,000-HORSE-POWER CURTIS STEAM TURBINE AND 2,000-KILOWATT GENERATOR, WITH SURFACE-CONDENSER INSTALLATION.

The turbine makes 750 revolutions per minute; the installation was built and is exhibited by the General Electric Co., Schenectady, N. Y.

turbines are represented, although none are of record-breaking size, the 2,000-kilowatt Curtis shown on the opposite page being the largest. Next in size is the 1,000-kilowatt Hamilton-Holzwarth, which being of a new type will be watched with interest. The 400-kilowatt Parsons horizontal turbine (page 17), which was put into operation on June 27, is to be kept in continuous service until the close of the Exposition. Some small DeLaval turbines are on exhibition in the Palace of Machinery, and others, driving generators and centrifugal pumps, are in motion in the Mining Gulch, shown below. The maximum or peak load on the main service plant is about 13,500 kilowatts.



DE LAVAL STEAM-TURBINE EXHIBIT IN THE MINING GULCH.
Showing steam turbines, generators, centrifugal pumps, and motors.

A serious disappointment is the absence of large gas engines. Two large foreign engines were expected, but a misunderstanding arose as to gas supply and erection charges, which led to their withdrawal. A 75-kilowatt Weber engine, with producer complete, burning charcoal, is in operation in the Gas, Steam, and Fuels Building, and a 250-horse-power Westinghouse in the Government fuel-testing plant in the Gulch. Two small Westinghouse gas generators and engines—one 225-horse-power horizontal and one 125-horse-power vertical, both shown on page 21, have been erected in the Palace of Machinery, and are running on city illuminating gas.

Almost every imaginable make and form of electrical generation and distribution for light and power may be found, alternating and

direct, at various voltages. Transformer stations are located at the main plant, and at various centers of distribution. The distribution is wholly by underground conduits.

In the power plant the auxiliaries are noticeable. All the principal types of barometric and surface condensers are in use. Many dry vacuum pumps are in operation, also a number of rotary and centrifugal pumps. Cooling towers are used for part of the condensers, while water which has passed over the cascades is drawn from the lagoons for the balance. It is difficult to understand why the latter plan was not employed for the entire cooling system, as was done at Paris.

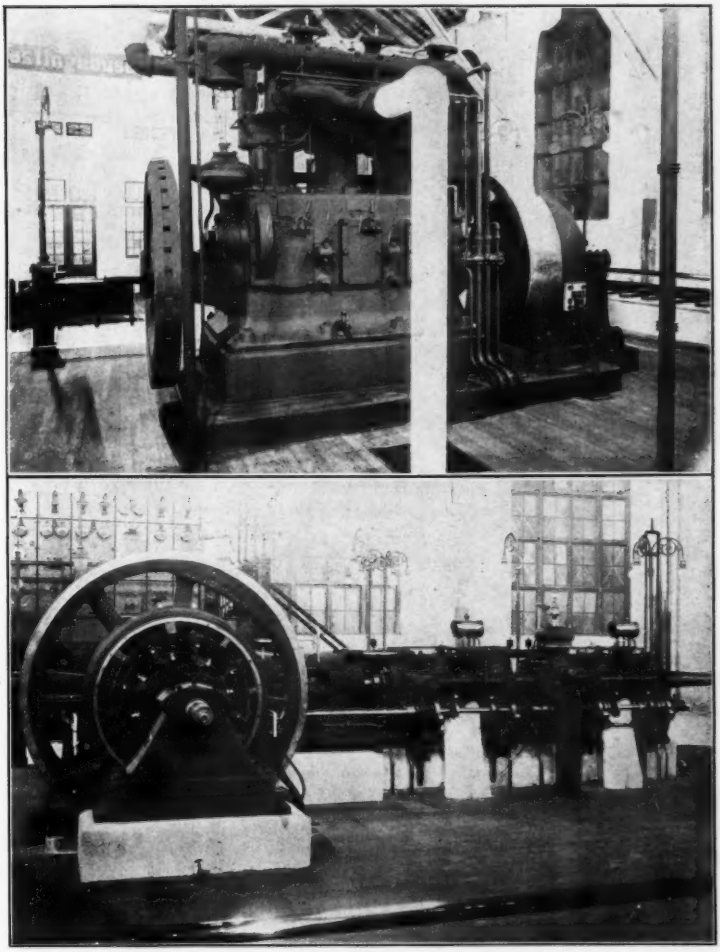
Among the concessions there are many interesting engineering features. The lighting of the Tyrolean Alps is from generators driven by Diesel motors, three units of 250 indicated horse power each being in operation, burning a light-gravity fuel oil, or distillate, from the Indiana fields, costing 4 cents per gallon. The fuel is injected by air supplied from independent motor-driven compressors. In the Philippine reservation the Government operates its own power plant, and incidentally exhibits many interesting details, such as the Filipino houses, water craft, manufactures, etc.

The Exposition organized its own system of collecting and disposing of garbage, erecting a 60-ton exhibit cremation plant for the purpose. All combustible matter is burned in the furnaces, and the sweepings, etc., are hauled away to dumps.

Much was expected originally of the department of refrigeration and ice making, whose display was to have been one of the features of the Fair. For some reason, however, the plan was abandoned, and the only exhibit of this kind is a 500-ton temporary plant operated as a concession, for the supply of ice on the grounds, and for circulating brine through refrigerator boxes, the underground lines extending some 7,000 feet from the plant. It represents good ordinary practice, but has no special or novel features.

Worthy of note are the ingenious methods of supplying power to machine tools, as shown in the Palaces of Machinery, Electricity, (page 22) and Manufactures. The individual motor drive, the combination of small machines into groups driven by a single motor, and the many ingenious methods of speed variation, will repay study.

Of great engineering interest is the coal-testing plant of the United States Geological Survey, erected and operated in the "Gulch" under an appropriation from Congress (page 23). The equipment consists of steam boilers, steam engines, electric generators and motors, a



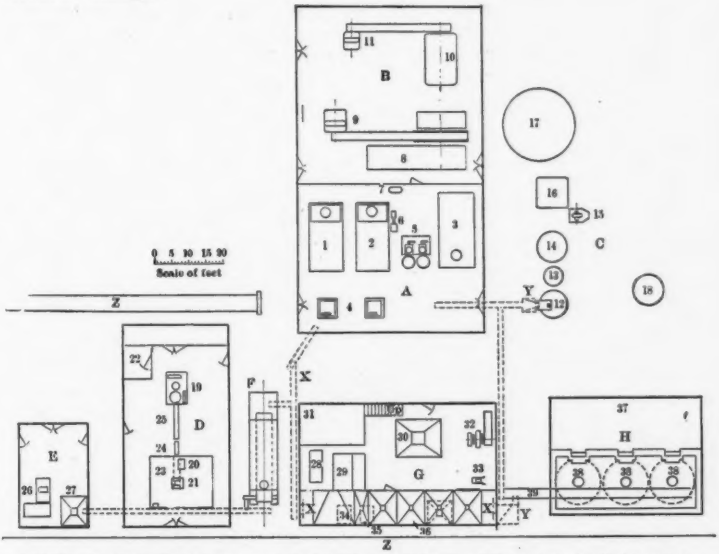
WESTINGHOUSE GAS ENGINES IN MACHINERY HALL.
Above is a 125-horse-power vertical single-acting gas engine; below is a 225-horse-power horizontal gas engine connected to three-wire double-voltage direct-current generator. Both are photographed by Cooper-Hewitt light.

complete gas producer, with economizer, scrubber, and holder, bee-hive coke ovens, a vertical gas engine, crushers, washers, driers, bins, one English and one American briquetting press, with outfits complete. There is also a complete plant of boiler- and engine-testing apparatus, and a well-equipped chemical laboratory, where calorific

THE PALACE OF ELECTRICITY.

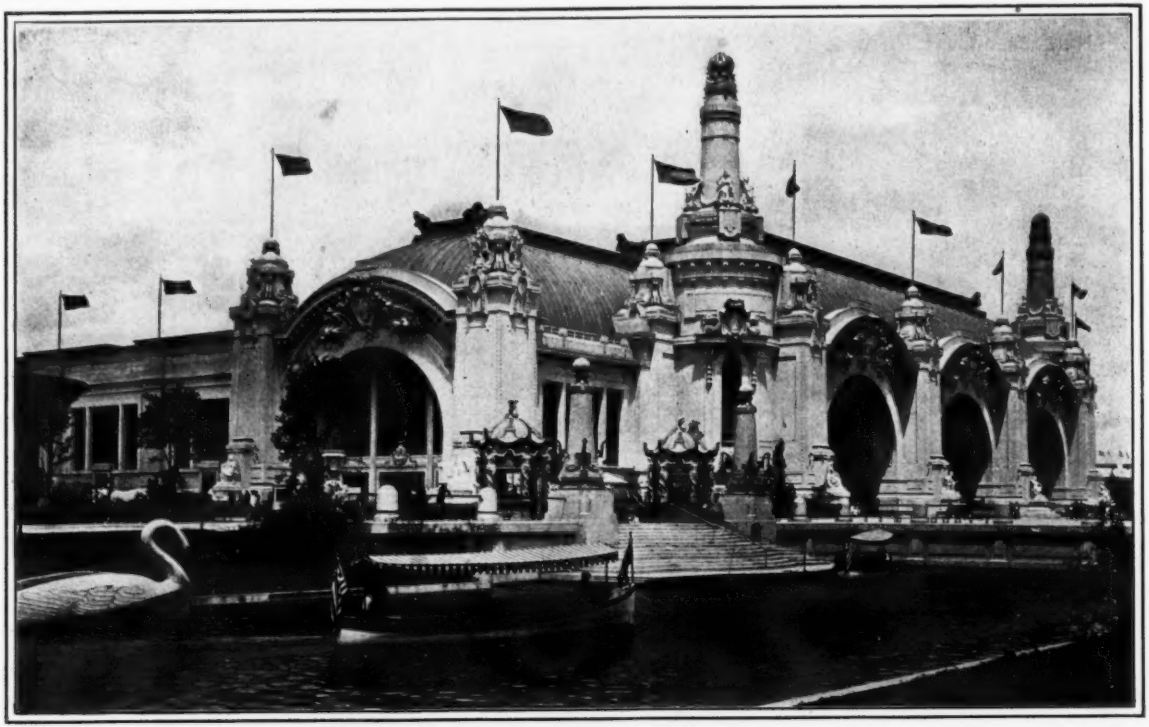
Copyright, 1904, by The Louisiana Purchase Exposition Co.

determinations and proximate and ultimate analyses of each fuel are made. All this work is in the hands of specialists of long training. The samples to be tested are selected at the mines by experts sent out for the purpose. On arrival, part of the coal is put through the gas-making plant, part through the coke ovens, part tested under the boilers, and part goes to the briquetting machines. A 250-horse-power gas engine is located along-side of a 250-horse-power Corliss engine, and both connected to electric generators. The coal will be transformed into electrical energy by both the steam and gas processes, and the results compared. The coke from the ovens will be analyzed, and then carefully tested in the Model Foundry near by. Both the equipment and the fuels are furnished to the government without charge.



UNITED STATES GEOLOGICAL SURVEY FUEL-TESTING PLANT, ST. LOUIS EXPOSITION.

Key to the lettering:—A, Boiler house; 1 and 2, Heine boilers; 3, fire-tube boiler; 4, coal weighing scales; 5, water ditto; 6, feed pump; 7, feed-water heater. B, Engine room; 8, 9, Allis-Chalmers-Bullock engine and belted generator; 10, 11, gas engine and belted generator. C, Gas producer; 12, R. D. Wood & Co. producer; 13, economizer; 14, scrubber; 15, tar-extracting fan; 16, purifier; 17, gas holder; 18, Foster gas producer. D, Briquette machine, Wm. Johnson & Sons, Leeds; 19, briquette machine; 20, pitch cracker; 21, hopper; 22, office; 23, mixer; 24, elevating fan; 25, elevator; E, Chisholm, Boyd & White briquette plant; 26, eggette machine; 27, hopper and storage bin; F, Bartlett-Snow dryer. G, Washery; 28, Century jig; 29, Link Belt jig; 30, sludge tank; 31, operating platform; 32, steam engine; 33, centrifugal pump; 34, Williams mill; 35, roller crusher; 36, hoppers. H, Coke ovens; 37, wharf; 38, La Clede Firebrick Co. ovens; 39, larry track; X, conveyors; Y, storage bins; Z, track sidings.



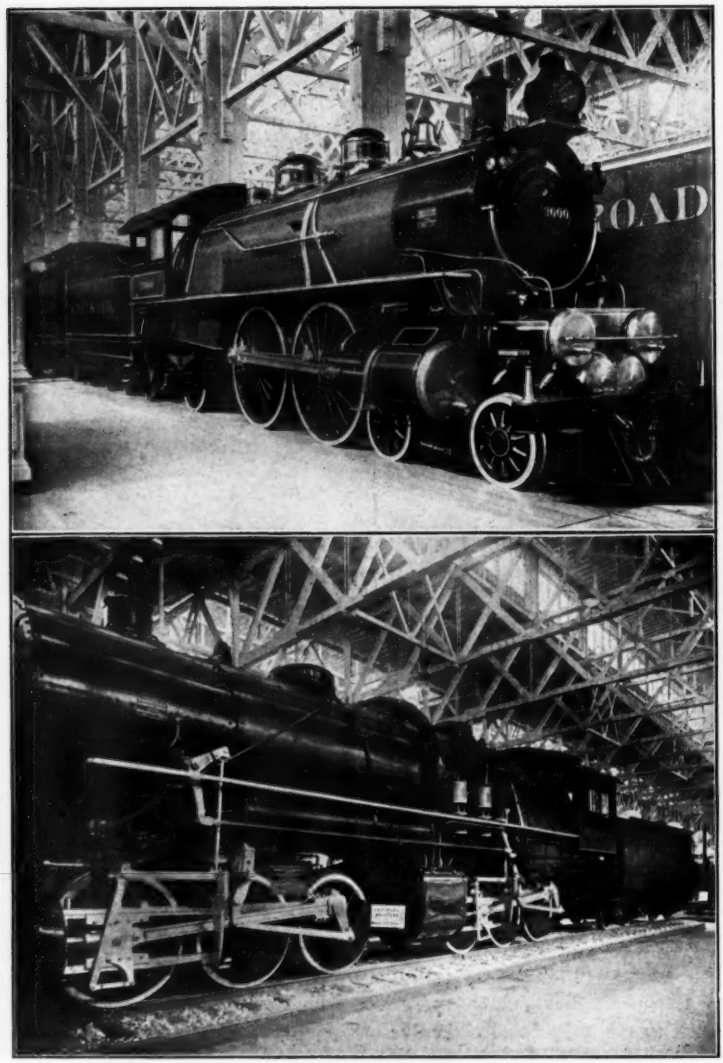
THE PALACE OF TRANSPORTATION.

Another installation of interest to engineers is the timber-preserving plant, located in the upper end of the Gulch, and operated by the Bureau of Forestry. Here the various processes for preserving railway ties and other timber will be tested. Afterwards sample ties of each lot are to be put into tracks in regular service, and careful records kept of the life and behavior of each tie.

The Model Foundry, also located in the Gulch, was built by the Exposition, and will interest many engineers. There the best apparatus and processes in modern foundry work have been erected and are in regular commercial operation. Improved cupolas, cranes, and moulding machines of all classes are shown.

THE PENNSYLVANIA RAILWAY LOCOMOTIVE-TESTING PLANT.

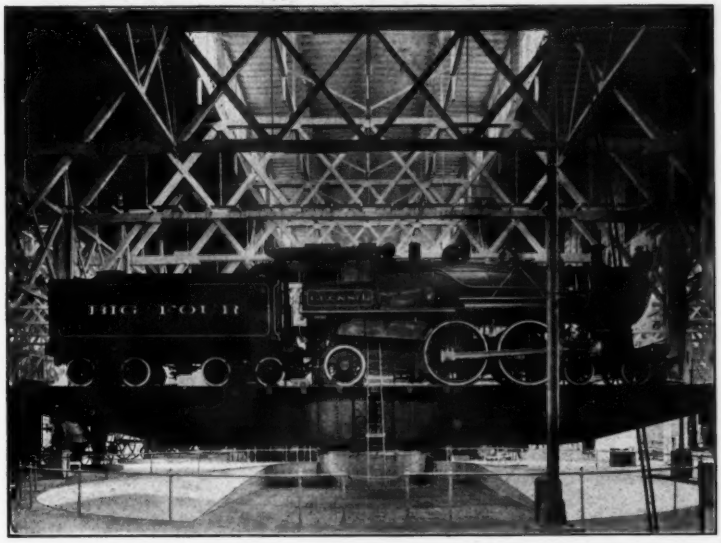
Engineers, particularly those interested in transportation, will find much to study in the locomotive-testing plant, erected and operated by the Pennsylvania Railroad in the Palace of Transportation. The equipment, as shown, is elaborate, and the engineers in charge are experts. Locomotives of various makes and types are being put through exhaustive tests, under varying conditions, at changing speeds, and with different fuels. This is the most exhaustive study of the locomotive ever made, and the results will be of great benefit. Bulletins are prepared and the results are to be published.



LOCOMOTIVES IN THE PALACE OF TRANSPORTATION.

Above is a N. Y. C. & H. R. engine built by the American Locomotive Co.—a four-cylinder balanced compound; the high-pressure cylinders are between the frames and drive the forward axle, the low-pressure outside, driving the rear axle; the cylinders are 15½ and 26 by 26 inches, heating surface 3,446 sq. ft.; pressure 220 lb., weight 200,000 lb. Below is a B. & O. articulated compound, Mallet system, carried on two groups of six drivers each; the high-pressure cylinders drive the rear group, which is rigidly connected to the frame, and the low-pressure drive the forward group, which is arranged as a swinging truck. Cylinders 20 and 32 by 32 inches, heating surface 5,585 sq. ft., pressure 235 lb., weight of engine alone 334,000 lb. Said to be the largest engine in the world.

Extensive series of tests of modern electric-railway apparatus and appliances are being made by experts of national reputation, on a line of double-track railway set aside by the Exposition authorities for the purpose.



BIG FOUR LOCOMOTIVE ON TURN TABLE.

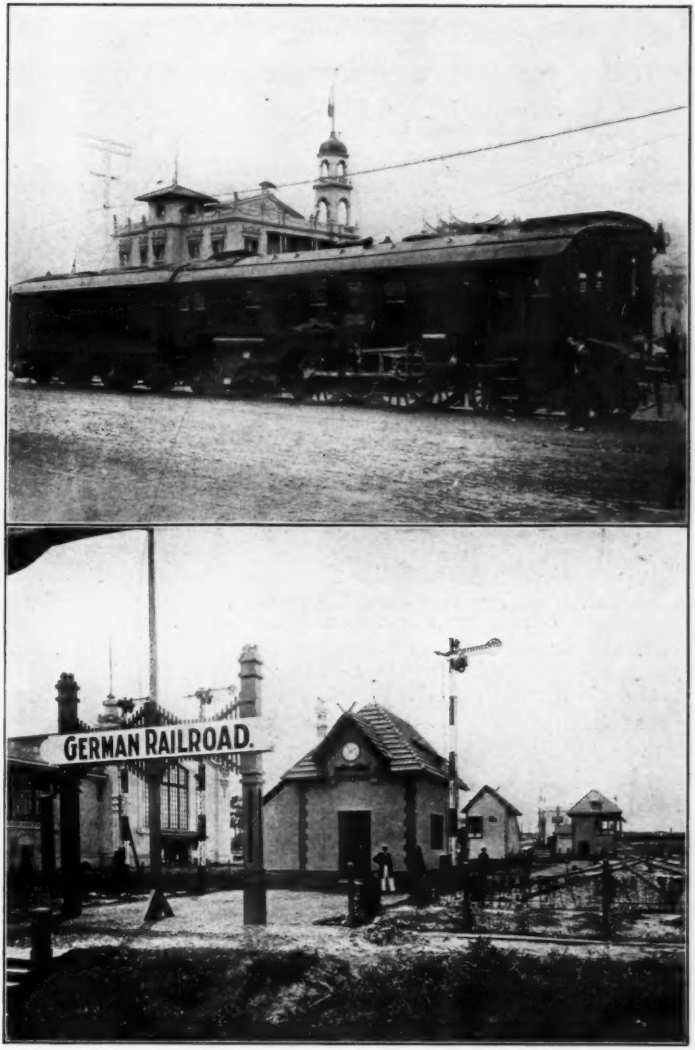
American Locomotive Co. Cylinders 20½ by 26 inches; drivers 79 inches; heating surface 3,196 sq. ft.; steam-pressure 200 lb.; weight of engine alone, 184,000 lb.

The engineering installations and exhibits are of such a varied character, and present so many interesting details, as to require far more space for their proper presentation than is available here. Only the principal features can therefore be discussed. The large and modern types of locomotives in the Palace of Transportation (pages 26, 27, 29, and 30) are of decided interest. Exhibits show both the largest (page 26) and the smallest locomotives in existence, the latter operating the miniature concession railway. A number of electric locomotives are shown, but none operated by compressed air. Ancient locomotives and tracks are interestingly shown. A German installation (page 29), erected just east of the Alaska Building, covers considerable area, and is an interesting full-sized exhibit of "safety in railroading." Part of the track is laid on wood ties, and attached by screws, and another part is laid on steel ties, the cost being practically the same. The block systems are shown in detail, part being operated by electricity and part by hand.

NORTH ENTRANCE OF THE PALACE OF MINES AND METALLURGY, ABOVE THE SUNKEN GARDEN.

Copyright, 1904, by The Louisiana Purchase Exposition Co.

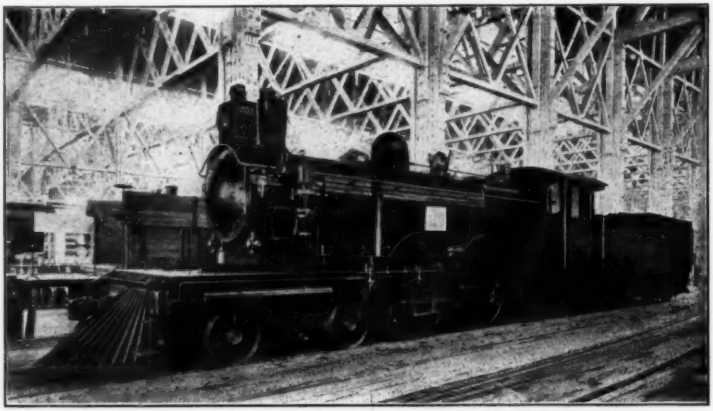
In the Palace of Transportation the exhibits of automobiles occupy a large area. There are many gasoline and electric machines, the former being by far in the majority. Only a few steam wagons are in evidence. On the model street are shown various forms of road and street construction. In the Palace of Mines and Metallurgy a very striking exhibit is the mammoth statue of Vulcan, 56 feet high and weighing 60 tons, exhibited by the city of Birmingham, Ala.



THE OUT-OF-DOOR GERMAN RAILWAY EXHIBIT, AND A HEAVY HIGH-SPEED GERMAN LOCOMOTIVE.

The outdoor exhibit shows stations, switch systems, signals, track, etc. The engine is a three-cylinder balanced compound by Henschel & Sohn, Cassel. The cylinders are all 20⅝ diameter, 24⅞ stroke, the high-pressure driving onto the front axle and the two low-pressure onto the rear; 2,776 sq. ft. heating surface, 200-lb. pressure; weight 85 tons. The cab is at the front end, and engine and tender are enclosed to diminish air resistance.

Much of engineering interest in mining is found in the Mining Gulch south of the Palace of Mines and Metallurgy, where many outdoor exhibits are in operation, including a full-sized working model of an anthracite coal mine.



LOCOMOTIVE FOR THE PENNSYLVANIA R. R., BUILT BY THE SOCIÉTÉ ALSACIENNE DE CONSTRUCTIONS MÉCANIQUES, OF BELFORT, FRANCE.

Four-cylinder balanced compound, de Glehn system; cylinders 14 3-16 and 23 5-8 by 25 3-16; heating surface 2,617 sq. ft.; pressure 227 1-2 lb.

Our old friend, the Ferris Wheel, now in its third location, is proving as interesting and successful as ever. As is well known, this wheel is 250 feet in diameter, and weighs 4,200 tons. Its dismantling in Chicago and its transportation and erection in St. Louis presented many interesting engineering problems. It is unfortunate, however, that it is now located on the lower instead of the higher level at the Fair.

Not the least interesting feature is the extent to which exhibits are in motion. Wherever possible, the machinery prepares the finished product under the visitor's eye. Particularly interesting are the plants spinning cotton, making shoes, incandescent lamps, and a distillery, numerous bakeries, and an electrical kitchen. The extensive use of maps, both plane and profile, and of complete models, is noticeable. Scattered all over the grounds are exhibits of moving pictures, showing a wide variety of subjects. So extensive is this method of advertising that it may well be termed one of the features of the Fair.

A characteristic development of the times is the almost total absence of belts, both in generating plants and in the power-distribution and motor installations. Those interested in modern electricity may

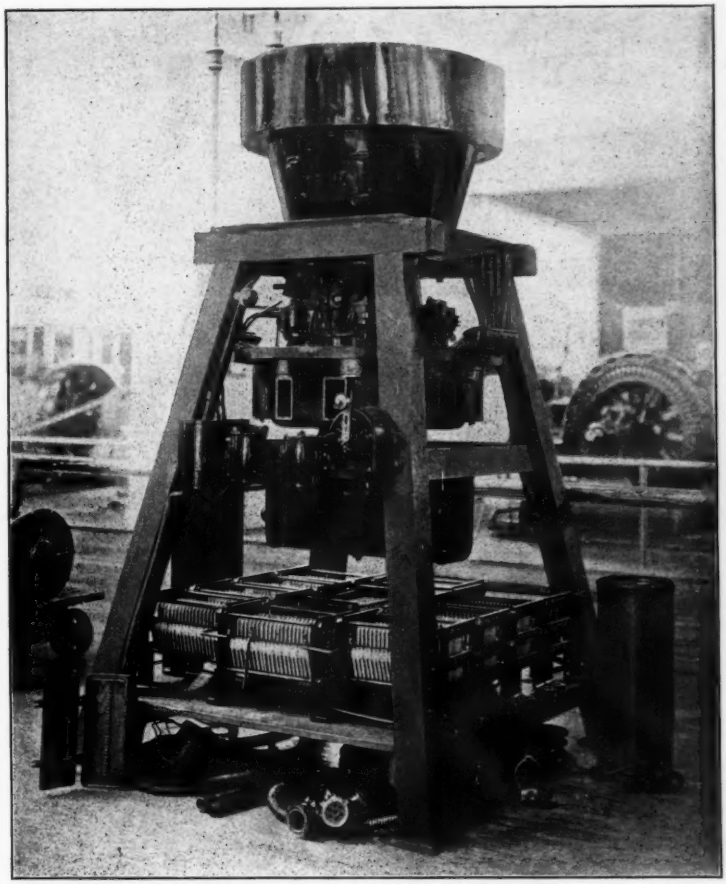
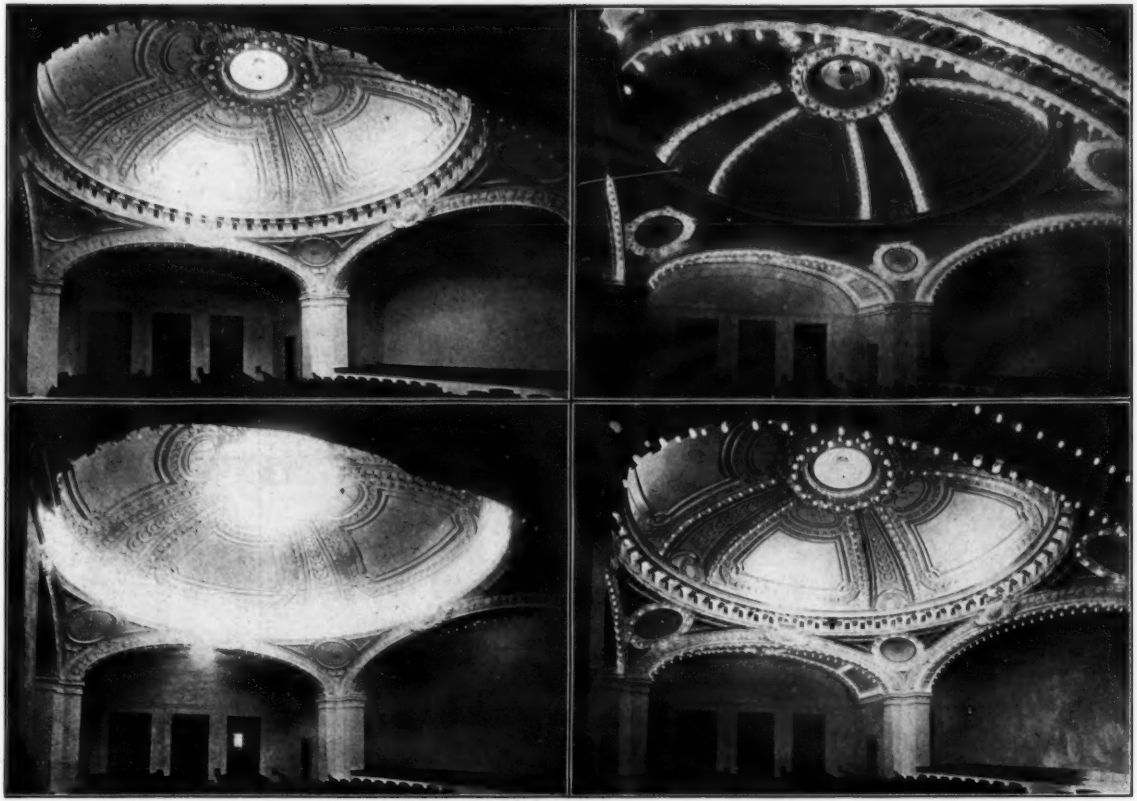


EXHIBIT OF PARTS, WESTINGHOUSE UNIT SWITCH SYSTEM OF MULTIPLE CONTROL, IN THE PALACE OF ELECTRICITY.

spend their time profitably in studying the many forms of alternating- and direct-current generation and distribution, the new switchboards, automatic telephone systems, wireless telegraphy—unfortunately in limited use at the Fair—the wireless telephone, rapid telegraphy, the Edison historical exhibit, the talking arc lamp, the extensive use of Nernst lamps, the Bremer arc lamp, and the Cooper-Hewitt mercury-vapor lamps. Much of interest to the engineer will be found also in the Palace of Education, where the equipment and accomplishments of many leading engineering schools are shown.



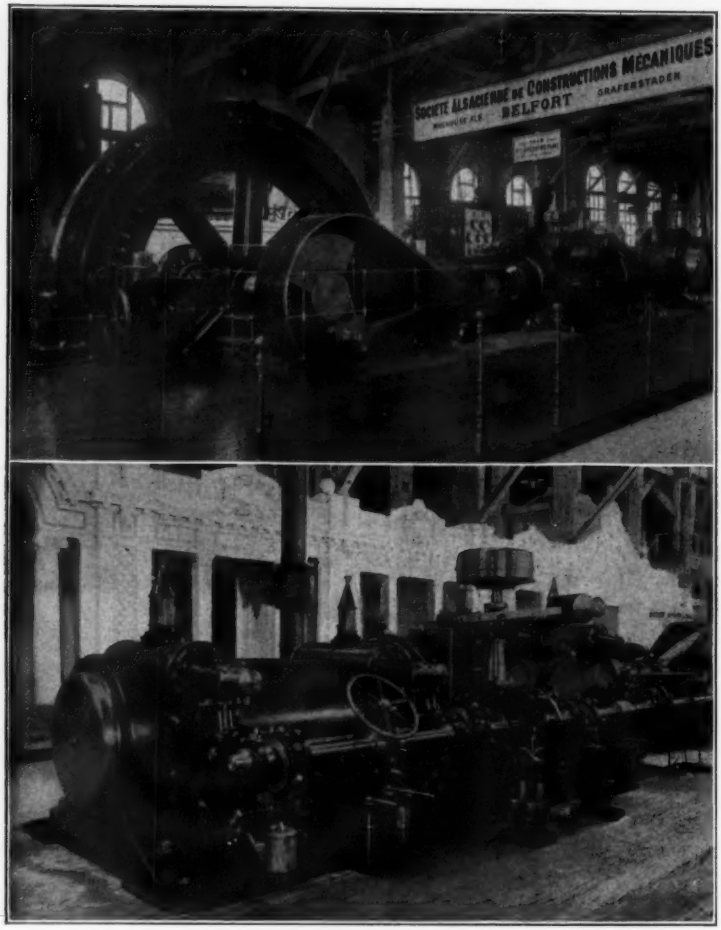
A COMPARISON OF SYSTEMS OF ELECTRIC LIGHTING, IN THE WESTINGHOUSE AUDITORIUM, MACHINERY HALL.
The upper illustration on the left shows the effect of lighting by Cooper-Hewitt lamps; next to that, on the right, the illumination by Sawyer-Man incandescent lamps. The lower view on the left shows the hall when lighted by Nernst lamps, while the effect in the lower right view is produced by the combination of Cooper-Hewitt mercury-vapor lamps, Sawyer-Man incandescents, Nernst glowers, and Bremer arc lamp.

No single engineering feature bears the same relation to this Fair that the Eiffel Tower did at Paris, or the Ferris Wheel at Chicago. There is, nevertheless, an immense amount of matter which will repay investigation, and a young engineering student could better forego a year at school than miss these opportunities. An investigator with a seeing eye and a discerning mind could occupy profitably every hour from the opening of the Exposition to its close. Few, of course, can give this much time, but an entire month could be well spent, and no engineer should remain less than a week.

Engineers differ as to the leading engineering feature of the Fair. Much depends upon the point of view. While neither the cascades, the illumination, nor the landscape engineering, present particularly novel features, yet the combination forms a grand and impressive piece of engineering. Of great practical benefit are the government fuel-testing and the locomotive-testing plants. The absence of belted machines, the distribution of power by electricity, the almost universal use of direct-connected motors, are hardly less notable. Epochs are here marked by the steam turbines, gas engines, and new forms of electric lamps.

While the Louisiana Purchase Exposition is magnificent from many points of view, and of such general interest as to appeal to all classes—and particularly to the engineer—it is a matter of regret that in some important directions the fullest engineering possibilities have not been realized. The money available, and the financial and moral backing of the United States Government, were ample grounds for expecting a stupendous exhibition. That this high result was not reached was due in part no doubt to the lack of recognition given the engineering profession, and also to the fact that the results aimed at were too great for even the splendid financial resources of this Fair. The work cost much more than it should. This was due largely to two causes:—First, the extreme haste necessary; and, second, the exactions of organized labor, the detailed story of which would form interesting reading indeed. Advantage was taken of the necessities of the Fair, and the scarcity of labor—often artificial,—to enforce outrageous demands of every kind.

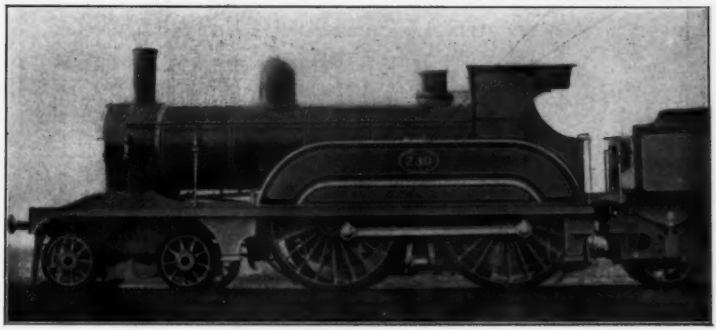
Those who have watched the progress of this enterprise from its inception, and who know the difficulties which had to be met, stand in admiration and awe at the splendid result. The final judgment of the critic who tries to be just, must, after all, be one of honor and congratulation, and not of petty criticism that some features have fallen short of the highest standards. Possibly no single visitor will find all



TWO VIEWS OF THE 1,000-HORSE-POWER HORIZONTAL TANDEM-COMPOUND STEAM ENGINE AND 700-KILOWATT, 2,300-VOLT, THREE-PHASE ALTERNATOR, BY THE SOCIÉTÉ ALSACIENNE DE CONSTRUCTIONS MÉCANIQUES.

The engine was built at the Mülhausen works, the generator at Belfort. The complete installation includes also surface condenser, vertical direct-driven air pump, electric-driven centrifugal pump, exciter, transformer, switchboard, alternating-current motor for circulating pump, and starting engine. It supplies current for the Exhibition arc-lighting service.

that he expected, but none will go away without an over-powering impression of the wonders he has seen. From whatever standpoint he has viewed the Fair, the general result will not be disappointing.



AN EARLY WORSDELL COMPOUND FOR THE GREAT EASTERN RAILWAY.

THE DEVELOPMENT OF THE COMPOUND LOCOMOTIVE IN ENGLAND.

By W. E. Dalby.

Professor Dalby's preceding article dealt with the work of Mr. F. W. Webb, the pioneer of the compound locomotive in Great Britain and one of its strongest advocates anywhere. The following paper concludes the review by a study of the work of the other British engineers who have been prominent in the development of the compound locomotive.—THE EDITORS.

AT the same time that compound locomotives were being tried on the London and North Western Railway, Mr. T. W. Worsdell was building a two-cylinder compound of the inside-cylinder type, the engine being jointly associated with the names of Mr. Worsdell and von Borries. The first of the kind was an express passenger engine built for the Great Eastern Railway Company, a photograph of which is shown just above. The high-pressure cylinder was 18 inches diameter and the low-pressure 26 inches, both having a stroke of 2 feet. The principal mechanical feature of this type was the arrangement used for starting the engine when the high-pressure valve happened to cover both steam ports. This will be understood from the diagrammatic arrangement, sketched in Figure 6, which shows a later automatic form, and not the actual gear used on 230. Normally the valve A is shut when the regulator is opened. If the slide valve of the high-pressure cylinder is in the position shown in the figure no steam can get into the cylinder at either end, and the engine fails to start. The valve A is then opened as shown in the sketch. Steam is thus admitted to the small cylinder B and the

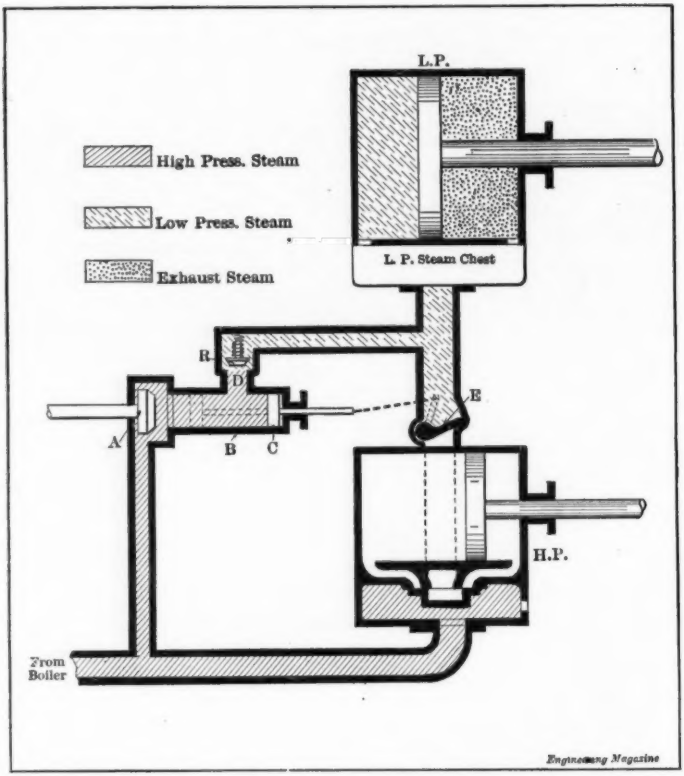


FIG. 6. DIAGRAM OF THE WORSDELL AND VON BORRIES COMPOUND LOCOMOTIVE.
The regulator and starting valves are open, and the engine is starting off the low-pressure cylinder alone.

piston C is pushed forward, thereby opening the port D and closing the intercepting valve E which is placed in the pipe which establishes communication between the exhaust port of the high-pressure cylinder and the steam chest of the low-pressure cylinder. Boiler steam makes its way through the reducing valve R by way of the port D and then flows to the low-pressure steam chest, being introduced into the supply pipe just below the intercepting valve. Directly the engine moves, steam is exhausted from the high-pressure cylinder and in its passage to the low-pressure cylinder opens the intercepting valve E, thereby pushing the piston C back to its normal (dotted) position and cutting off the boiler supply to the low-pressure pipe at

the port D. The action is entirely automatic once the driver has opened the valve A. It will be understood that were it not for the intercepting valve, E, the steam introduced directly into the low-pressure supply pipe through the reducing valve R would make its way through the exhaust port of the high-pressure cylinder and appear as a back pressure on the high-pressure piston, thus trying to reverse the engine. The engine would have to start, in fact, with the reduced pressure of steam acting on the difference of areas between the low- and the high-pressure cylinders. Figure 7 shows the actual arrangement as applied to the North Eastern Railway engine shown on page 35.

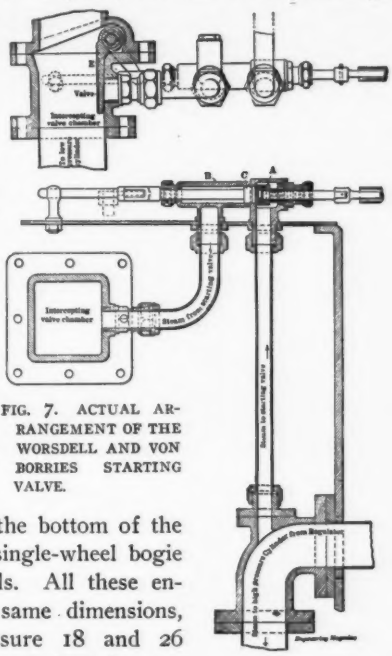
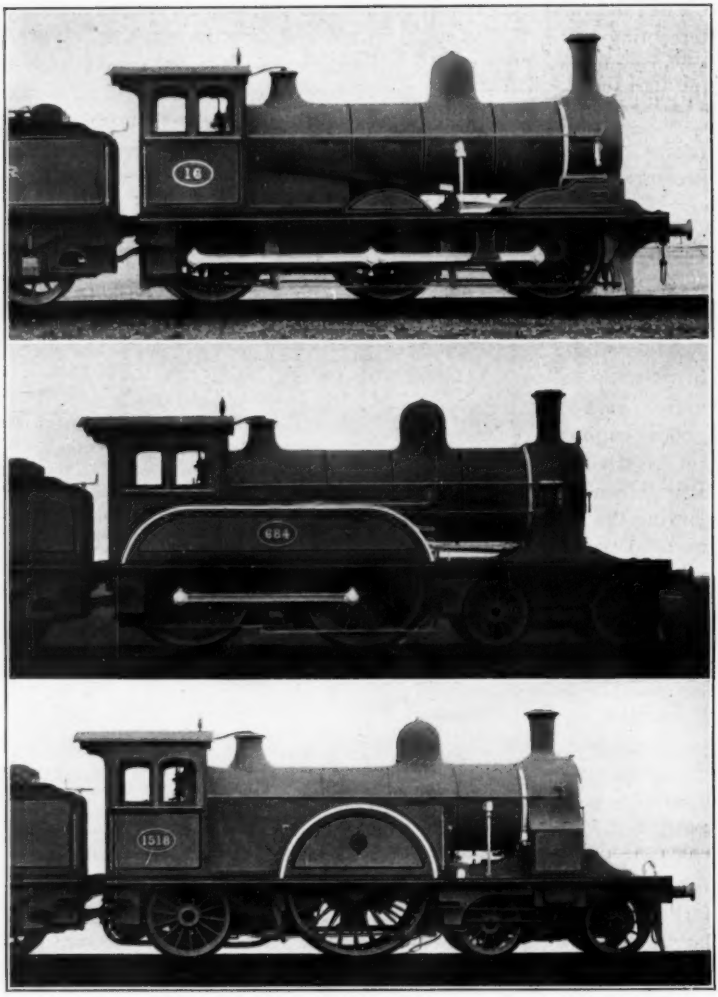


FIG. 7. ACTUAL ARRANGEMENT OF THE WORSDELL AND VON BORRIES STARTING VALVE.

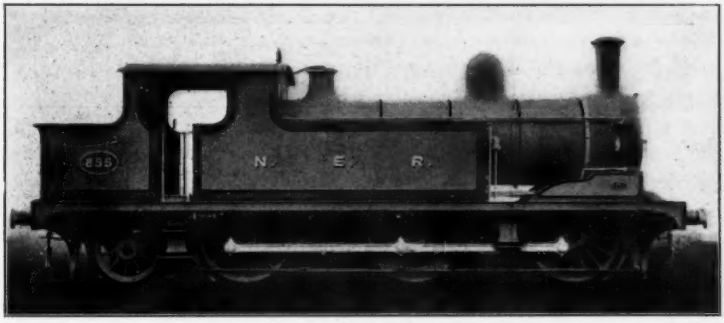
The Great Eastern express passenger engine built in 1885 was followed by nine more. In 1887 a compound goods engine was built for the North Eastern Railway. It is shown on the next page. During the period from 1887 to 1890 the system was applied to about two hundred and seventy engines on the North Eastern Railway. There were twenty-seven of the kind shown in the second illustration on the following page, ten like the engine at the bottom of the group on page 38, and ten single-wheel bogie expresses with smaller wheels. All these engines had cylinders of the same dimensions, namely high- and low-pressure 18 and 26 inches diameter respectively, both being 24 inches stroke, and boilers of practically the same size. In 1890 a larger single-wheel bogie express type appeared. The low-pressure cylinder was increased to 28 inches diameter, and the boiler was increased in size. The comparative sizes of these engines will be found in the table at the end. In addition to these passenger engines there were one hundred and seventy-one compound, six coupled goods engines, and fifty-one tank engines; a view of the latter type is given on page 39. The most recent type of compound locomotive used



EARLY TYPES OF COMPOUND LOCOMOTIVES ON THE NORTH EASTERN RAILWAY.

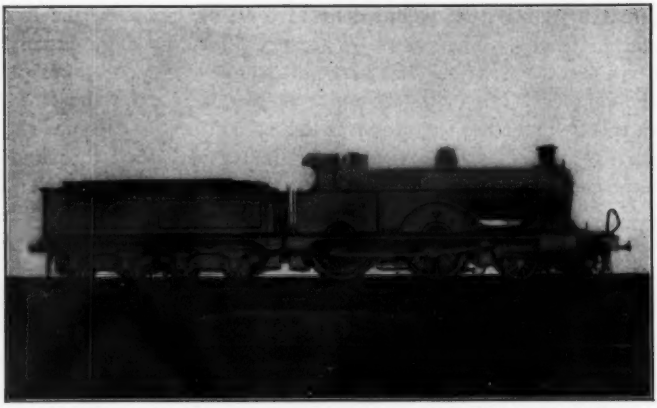
The uppermost is a compound goods engine of 1887; next comes a representative of a group of twenty-seven, and at the bottom one of ten. Both these types appeared between 1887 and 1890. All have cylinders 18 and 26 inches by 24 inches stroke.

in Great Britain is that patented by Mr. W. M. Smith of the North Eastern Railway. The engine is arranged for two-stage expansion through three cylinders. The first part of the expansion takes place in the high-pressure cylinder, which is placed between the frames; from this cylinder the steam is transferred to the low-pressure stage, which for convenience of working is divided between two cylinders arranged on the outside of the frames, the engine presenting the appearance of an ordinary outside-cylinder coupled engine. The three cranks operated by these cylinders are all placed on one axle, one inside and two outside, the outside cranks being coupled to a pair of trailing wheels. The two outside cranks are at right angles with each other, the inside crank being placed at 135 degrees with each of them—that is to say, the inside crank bisects the re-entrant angle



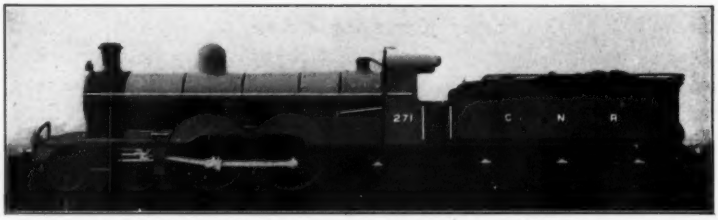
COMPOUND TANK ENGINE, NORTH EASTERN RAILWAY.

formed by the two outside cranks. The method of operating the engine is extremely ingenious. The driver has it in his power to increase or decrease the pressure in the low-pressure valve chests at will within certain pre-arranged limits. Thus he may increase it almost to boiler pressure, in which case the high-pressure piston is practically in equilibrium and the engine works as a simple outside-coupled with two large cylinders and 200-pound initial steam pressure. This particular way of working is never actually used, because there is not sufficient adhesion available, but it may be approached by the driver as nearly as he pleases. On the other hand, he may reduce the pressure in the low-pressure valve chests to a certain fixed minimum, thereby reducing the back pressure on the high-pressure piston and increasing the work done by that cylinder. Further, if the expansion in the high-pressure cylinder is carried so far that the exhaust pressure falls below what is fixed as desirable in the low-



COMPOUND BUILT BY MR. S. W. JOHNSON, FOR THE MIDLAND RAILWAY.

pressure valve chests, high-pressure steam is admitted automatically to make the pressure up, this style of working being called by the inventor "semi-compound." This control of the working is obtained in the simplest way possible. The matter will be made clearer by reference to the diagrammatic representation of the engine in Figure 8. It should be understood in studying this diagram that the low-pressure cylinders are displaced from their true position; actually they are all in a line across the engine. Boiler steam is shown by the cross hatching in full lines, the steam in the space between the high- and low-pressure cylinders by the cross hatching in dotted lines. The exhaust steam from the low-pressure cylinders is not indicated at all, since it passes in the usual way into the blast pipe. It will be noticed first that boiler steam can find its way into the low-pressure cylinder supply pipe, R, R, R through the valve A. The valve itself is connected by means of a spindle to a piston valve B, the two forming a kind of double-beat valve. A second valve C will be seen above this, placed so that it controls the admission of steam to the upper



FOUR-CYLINDER COMPOUND LOCOMOTIVE, GREAT NORTHERN RAILWAY OF ENGLAND.

face of B. Consider first that this valve, C, is closed, or, what amounts to the same thing, that the driver by turning the handle H has compressed the spring D onto the valve so that the boiler steam cannot open it. There will be no pressure acting on B; consequently the boiler steam will lift A and pass into the low-pressure supply pipe at a pressure determined by the spring E, which may be arranged to throttle the boiler pressure down 30 or 40 pounds, say. If this spring be omitted, steam will pass in at full boiler pressure. Secondly, assume the valve C to be wide open, in which case the driver may be

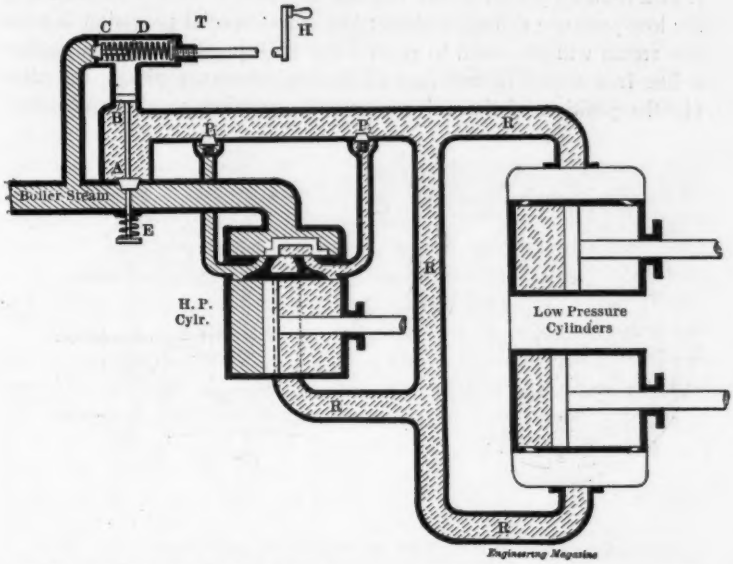
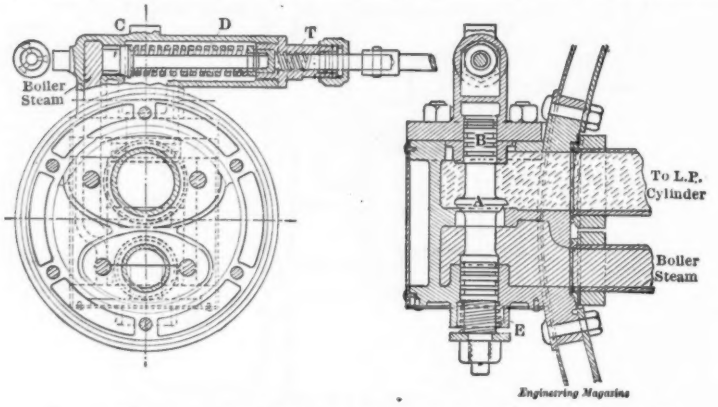


FIG. 8. DIAGRAM OF CYLINDERS FOR MR. W. M. SMITH'S COMPOUND LOCOMOTIVE.

supposed to have turned the handle H so that the compression on the spring D is reduced to nothing. Boiler steam will then find its way into the space over B, and will exert a pressure to oppose the opening of the valve A. Assuming that the ratio of the areas of the two valves, A and B, is 2 to 1, steam will then be passed into the low-pressure space at one-half the boiler pressure. It will now be readily seen that the pressure at which steam is passed by the valve A into the low-pressure pipes can be varied between the minimum fixed by the area of B, with C open, and the maximum fixed by the strength of E with C closed; and that this control is obtained by merely adjust-

ing the compression of the spring D, which the driver can do at any moment from the cab. For a given compression of the spring D the action of A is entirely automatic. A gauge in the cab gives the pressure of the low-pressure supply, and this pressure is maintained by the automatic action of the valve A, providing, of course, sufficient steam is forthcoming from the boiler. There is a third important part of the arrangement to consider. Suppose the high-pressure valve at starting happens to cover both the steam ports so that no steam can get into the high-pressure cylinder at either end. Steam will pass A at a reduced pressure, and the engine will thus be able to start with the low-pressure cylinders alone; but unless special provision is made this steam will also tend to reverse the high-pressure engine, because it has free access to one face of the high-pressure piston, the other (in the position of the valve assumed) sustaining only atmospheric



FIGS. 9 AND 10. ACTUAL FORM OF MR. W. M. SMITH'S REDUCING VALVE.

pressure. This difficulty is got over by putting the steam ports in communication with the low-pressure supply pipes through the non-return valves P_1 and P_2. In this way the high-pressure piston is thrown into equilibrium, because whatever pressure acts on the face of the piston in communication through the exhaust port with the low-pressure supply, an equal pressure is brought to bear upon the other face through steam passing one or other of the valves P. If the steam in the low-pressure supply pipes ever reaches the boiler pressure, the effect of the valves, P_1, P_2, is to keep the high-pressure piston working in a state of equilibrium, the engine being therefore a simple one.

The actual form taken by the reducing valve, A and B, is shown in Figures 9 and 10, which are lettered similarly to the diagram. Figure 11 also shows one of the non-return valves, P. Figure 12 shows a valve which is placed on the steam chest of the high-pressure cylinder for destroying the vacuum in the cylinder when the engine is running with steam shut off.

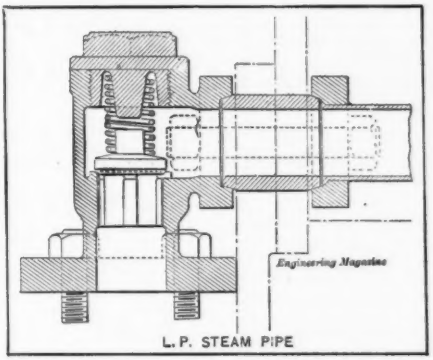


FIG. 11. NON-RETURN VALVE, NORTH EASTERN RAILWAY COMPOUNDS.

Directly the pressure falls below that of the atmosphere the large valve A lifts, its lower face being acted upon by the atmosphere, and in lifting opens the small steam valve B. Steam rushes through the conical orifice C, and air and steam together destroy the vacuum which otherwise would have been destroyed by drawing air and gases loaded with grit down the blast pipe through the exhaust passages of the valves.

The diagram shows a valve of the ordinary type in connection with the high-pressure cylinder. It should however be stated that a piston valve is used for the high-pressure cylinder in the actual engine. This piston valve is of a type invented by Mr. Smith, the object of its special form being to allow trapped water to get away through the valve in the way it passes the ordinary slide valve. Briefly, the valve is a piston valve in form, but the usual packing rings, assuming one broad one at each end, are cut into three separate portions, each portion actually forming a small slide valve, being

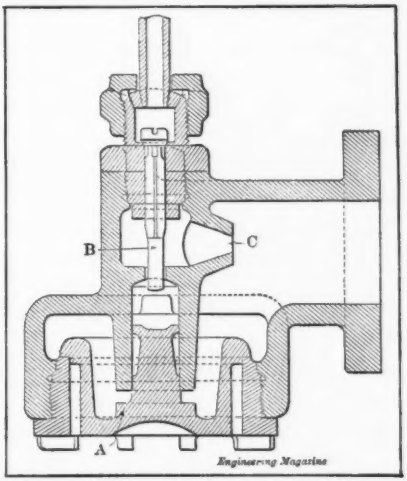


FIG. 12. VALVES FOR DESTROYING CYLINDER VACUUM, NORTH EASTERN COMPOUNDS.

TABLE I.

Designation.	Diameter of Driving Wheels.	Total Weight on Driving Wheels in Tons.	Boiler Pressure.	Vol. of H. P. Cylrs. Cu. Ft.	Vol. of L. P. Cylrs. Cu. Ft.	Ratio, Vol. L. P. / Vol. H. P.	Total Heating Surface, Sq. Ft.	Grate Area, Sq. Ft.	Ratio, Heating Surface—Grate Area.	Cylinders. H. P.	Cylinders. L. P.
Experiment, 1882	6 ft. 6 in.	....	...	2.88	7.6	2.64	1083.5	17.1	63.	11½ by 24	26 by 24
Experiment class, 1883....	6 ft. 6 in.	27.8	150	3.68	7.6	2.06	1083.5	17.1	63.	13 by 24	26 by 24
Dreadnought class, 1884...	6 ft. 0 in.	30.0	175	4.28	9.8	2.29	1401.5	20.5	68.3	14 by 24	30 by 24
Teutonic class, 1889.....	7 ft. 0 in.	31.0	175	4.28	9.8	2.29	1401.5	20.5	68.3	14 by 24	30 by 24
Greater Britain class, 1891.	7 ft. 0 in.	....	175	4.92	9.8	1.99	1540.9	20.5	75.	15 by 24	30 by 24
8-coupled goods class, 1893.	4 ft. 3 in.	....	175	4.92	9.8	1.99	1489.0	20.5	72.	15 by 24	30 by 24
John Hicks class.....	6 ft. 3 in.	....	...	4.92	9.8	1.99	.....	....	....	15 by 24	30 by 24
Black Prince class, 1897...	7 ft. 1 in.	34.2	200	4.92	8.94	1.82	1400.	20.5	68.3	15 by 24	20½ by 24
6-coupled goods class, 1903.	5 ft. 0 in.	44.0	200	4.92	8.94	1.82	1753.	20.5	85.5	15 by 24	20½ by 24
G. E. R. Express, Passr., 4-cyl., 1885	7 ft. 0 in.	29.7	160	3.53	7.38	2.09	1200.	17.3	69.4	18 by 24	26 by 24
N. E. R. Goods, 6-coupled, 1887	5 ft. 0 in.	41.85	160	3.53	7.38	2.09	1136.	17.23	66.	18 by 24	26 by 24
N. E. R., 4-coupled express, 1887	6 ft. 8 in.	30.5	170	3.53	7.38	2.09	1323.	17.33	76.4	18 by 24	26 by 24
N. E. R., 4-coupled bogie express, 1888	6 ft. 8 in.	30.5	170	3.53	7.38	2.09	1323.	17.33	76.4	18 by 24	26 by 24
N. E. R., bogie, single, 1889.	7 ft. 0 in.	18.0	175	3.53	7.38	2.09	1136.	17.23	66.	18 by 24	26 by 24
N. E. R., bogie, single, 1890.	7 ft. 6 in.	17.75	175	3.53	8.55	2.42	1139.	2.07	55.	18 by 24	28 by 24
N. E. R., (1619), 1899....	7 ft. 0 in.	....	...	4.27	8.72	2.04	1324.	23.0	57.6	19 by 26	20 by 24
M. Ry., (2631 and 2), 1902	7 ft. 0 in.	38.8	195	4.27	10.04	2.34	1598.†	26.0	61.5‡	19 by 26	21 by 26

† With serve tubes, 1720. ‡ With serve tubes, 66.2.

pressed onto the cylinder face of the ports by the steam pressure, and being free to fall away a short distance under the pressure of trapped water. A special exhaust ring prevents steam passing from the pressure to the exhaust side of the valve. By this arrangement the actual area of sliding surface is considerably reduced, and it has been stated that the wear of these segmental valves is only one-eighth of the wear of a slide valve of the usual type.

This system was first applied when Mr. Wilson of the North Eastern Railway rebuilt engine No. 1619, in 1898. A photograph of the engine in its rebuilt form was shown last month.* To increase the steaming capacity of the boiler, cross tubes were applied through the firebox. The engine has done exceedingly good work and at the present time is working, unassisted, the heaviest and fastest trains between York and Edinburgh.

Mr. Samuel Johnson built two engines of this type for the Midland Railway and one of these is shown on page 40. They have been running since August, 1902, between Leeds and Carlisle, working the fast expresses. This section of the road includes gradients of 1 in 100, 15 miles long. Full particulars of the fine performance of engine No. 2631 will be found in *Engineering*, Feb. 6 and March 27, 1903. Mr. S. W. Johnson has just completed the fifth engine of this type.

The table on the opposite page brings together the principal dimensions of the engines which have been illustrated and discussed.

An examination of the figures in the table will show that considering the London and North Western engines from the Dreadnought class down to the latest type given, the grate area is the same, namely 20.5 square feet; and that with the exception of the last on the list, the North Eastern engines have all practically 17.3 square feet of grate. The recent Midland engines have, however, 26 square feet of grate area. Assuming that all these engines alike burn as a maximum 100 pounds of coal per square foot of grate per hour when taking their full loads at express speed, and that the calorific power of the coal is 13,000 British thermal units, it follows that the maximum amount of heat developed in the firebox per second in the several cases is:

N. E. R. compounds .....6,240 B. T. U. per second
L. & N. W. compounds .....7,400 " " " " "
Midland compounds .....9,380 " " " " "

The maximum steady horse power of the engine will depend upon

*THE ENGINEERING MAGAZINE, September, 1904, page 953.

the proportion of these quantities which can be utilised as work in the cylinders. It may be fairly assumed that the boiler efficiency in each case is 70 per cent., so that the quantity delivered to the cylinders by the steam pipe will be:

N. E. R. compounds 4,370
L. N. W. compounds 5,180
Midland compounds 6,560

To estimate the horse power from these figures we must know:

(1) The theoretical engine efficiency,
(2) The efficiency ratio.

Applying the standard adopted by the Institution of Civil Engineers to find (1), the efficiency is computed from the expression

$$\text{Efficiency} = \frac{(T_1 - T_2)\left(1 + \frac{L_1}{T_1}\right) - T_2 \log e \frac{T_1}{T_2}}{L_1 + (T_1 - T_2)}$$

where T_1 = the absolute temperature of the steam corresponding to the initial absolute pressure.

T_2 = the absolute temperature of exhaust, taken at 673 degrees (212 degrees F.)

L_1 = latent heat of the steam at temperature T_1.

Figure 13 shows a curve from which the theoretical efficiency can be taken and which was plotted from the above formula. The curve shows how the efficiency increases as the temperature of the steam is increased. To find (2) is not an easy matter. The crosses on the diagram show the efficiency as obtained in Messrs. Adams' and Pettigrews' experiments on the London and South Western Railway with an express locomotive. The dots show the efficiencies obtained in Prof. Goss' experiments with the simple engine Schenectady at Purdue. The highest dot and the lowest cross each indicate an efficiency ratio of about .55. Drawing the line CD therefore so that it cuts off .55 of the vertical distance between the base and the theoretical efficiency line AB, the maximum horse power may now be computed. Judging by the results stated to have been obtained with compound locomotives, the saving with 200-pounds pressure may be taken at 15 per cent. It is unlikely that the saving would be more than half this at 120 pounds per square inch. Taking these two values and sketching in the dotted curve, it may fairly be assumed that it represents the efficiencies of compound engines for pressures between 120 and 200 pounds per square inch. This curve is, of course, only an assumed one. But in the first place CD may be taken to rep-

resent what a simple engine should do in the best circumstances, because the efficiencies have been realised in practice. The compound curve should therefore certainly be above this.

Considering now the case of the Black Prince type, where the pressure is 200 pounds per square inch (215 absolute) the proportion of the heat supplied which can be turned into useful work is, reading the efficiency from the curve, 0.118, that is, 611 B. T. U. per second, which corresponds (dividing by 0.71 the B. T. Units per second corresponding to one horse power) to 860 indicated horse power. The corresponding horse power of the Dreadnought class with an efficiency of 0.113 is 824, not greatly less than the Black Prince class. In the North Eastern engines it will be seen that the initial pressure varies from 160 to 175 pounds per square inch, corresponding to efficiencies of 0.108 and 0.113. In the case of the engines with the lower pressure the maximum horse power is 664, increasing to 696 with the higher pressure. The Midland engine has an efficiency of 0.117, consequently the maximum horse power would be about 1,090. These figures are, of course, merely comparative, and represent steady conditions of running with uniform boiler pressure; but they serve to show how locomotives may be compared with one another in a thermodynamic sense and to mark out with reasonable accuracy the upper limits of the horse power which may be expected under the fuel consumption assumed.

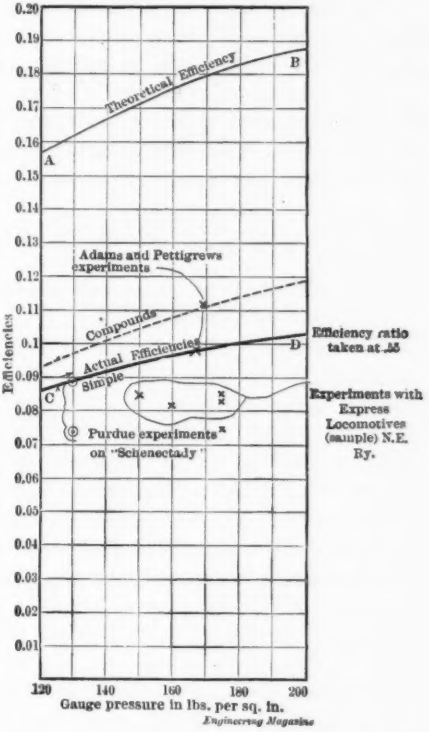


FIG. 13. THEORETICAL AND EXPERIMENTAL EFFICIENCIES OF COMPOUND LOCOMOTIVES.

A study of these curves and the examples worked out will show how much more effectively an increase of grate area increases the power of the engine than an increase of pressure, even when that increase is accompanied by compounding. The maximum horse power which may reasonably be expected from a given engine may be calculated from the following formula, which only represents the process used to obtain the horse power in the above illustrations,

$$\text{I H P} = \frac{Q\ A\ C\ \beta\ \eta}{2545}$$

in which

Q = coal burnt per square foot of grate area per hour,
A = grate area in square feet,
C = calorific value of the fuel in British thermal units,
β = boiler efficiency,
η = engine efficiency.

In the series of experiments with express locomotives carried out on the N. E. R. R. β had an average value of 0.63 nearly, and η as indicated on Figure 13, had an average value of 0.081. The result of five experiments on an express locomotive by Messrs. Adams & Pettigrew gave values 0.72 and 0.1 for β and η respectively. The difficulty in making complete thermodynamic tests of a locomotive on the road is exceedingly great, because all the factors of the test are continuously varying. The records of the coal consumption per mile afford a direct and valuable way of comparing the performance of a set of locomotives employed on the same service, but the records of engines on different services cannot be compared.

It is to be regretted that there is no locomotive-testing plant in England where the actual performance of a locomotive may be measured in a way to obtain the number of heat units per indicated and per draw-bar horse power. The United States is to be congratulated in the possession of more than one establishment of the kind, and at the present time the focus of scientific research on locomotive economy is undoubtedly situated at Purdue University.

My acknowledgements are due to Mr. George Whale, of the London and North Western Railway; Mr. Wilson Worsdell, of the North Eastern Railway, and Mr. Smith, for kindly sending me the photographs from which the views illustrating this article have been prepared.

THE INTRODUCTION OF HIGH-SPEED STEEL INTO A FACTORY.

By A. D. Wilt, Jr.

There have been few modern developments of machine-shop practice—if any—which offered such economies and required such changes in equipment and methods as the new air-hardening steels. The great interest of Mr. Wilt's articles is his direct attack upon the practical aspects of the introduction of high-speed steel, and his definite plans for meeting all the problems, both mechanical and managerial.—The Editors.

A PRECEDING article reviewed the specific mechanical problems attending the replacement of carbon-steel by high-speed steel—especially the methods to be followed in hardening small tools, made of the newer material, for the various classes of machines in the shop, the apparatus and temperatures to be employed, and finally the changes in the machine tools themselves necessitated by the higher duty demanded of them. It remains to take up certain questions more general but yet more fundamental—the problems of management, wages, and costs, which are radically changed by the change in rate of production effected by the high-speed steels. In other words, taking into account not only the mechanical but also the human factors:—

III. What Is the Best Plan for Introducing High-Speed Steel into a Factory?—

Many new processes and machines lately brought forward have involved changes in piece-work prices, speeds, feeds, machinery, etc., but few have involved such a general and extensive change as high-speed steel. For this reason it requires most careful consideration in order to secure highest efficiency. In the first place it is impossible to know just what increase in production is possible and practical without systematic experimenting. A manufacturer might know in a general way what results should be obtained, from what other factories have obtained.

Just what should be accomplished in any one factory without an exhaustive try-out by competent men cannot be predicted. This steel must be adapted to conditions as they exist in each factory, and it is obvious that to attain the highest efficiency this adaptation must be made in a thorough manner and not by guess-work. The only thorough manner is for a capable man to actually run the machine

under working conditions with high-speed-steel tools as well as carbon-steel tools, and to obtain results from comparison.

It is a custom in some factories for the foremen to try out the jobs. They do this in some cases by actually running the machine, and in other cases by simply watching the workman run the machine. Some foremen can set a fair price in the latter way when they have had long experience with carbon-steel tools, but when any foreman attempts to set a price in this manner using high-speed steel, he cannot for some time tell anything about it. He must actually run the machine, and even if he does so he cannot tell at first what should be accomplished. He must learn by experience. Since the speed at which tools must be run to attain the highest efficiency varies with each job, the best results cannot be obtained without a try-out of each one.

As some factories have as many as 25,000 or 30,000 different piece-work prices it is impossible that each of these be tried out for any length of time. It is possible and practical, however, that enough prices be tried out on each different machine and class of part to enable an understanding of what prices should be set for similar jobs which are not of enough magnitude for an extensive try-out.

This leads to the necessity of keeping certain data for consultation. It is evident that a skilled man running a machine for a time could obtain some valuable data, relating not only to piece-work prices, but to the conditions under which each machine should be run to attain the highest efficiency. He might discover that one machine is not so well adapted as another to turning out a certain part, or he might find that a heavier machine would greatly increase the output. Why not combine his experience with that of half-a-dozen other men?

This can be accomplished if the responsibility for the proper introduction of the steel be fixed on a certain number of men—the necessary number depending on local conditions, such as the number of employees and different types of machines in use.

A method employed with great success in several shops with which I have had experience is to establish a high-speed-steel committee, which is responsible for all changes in tools, machinery, piece-work prices, etc., incurred by the adoption of high-speed steel. The members of this committee run actual try-outs, or tests, on all machines in the shop. They do not entrust the securing of such valuable data to the workmen, but operate each machine under working conditions. Each member acquires data, which are submitted to the committee as a whole for conjoined consideration.

This committee should not only study the question by a comparison of observations made among its members, but should be instructed by men from the outside, experts on high-speed steel, who could tell its members what other factories have done in regard to increasing output, regulating costs, etc. The personnel of such a committee would necessarily depend upon conditions in each shop. If it were a union shop its members obviously could not be union men, and foremen or assistant foremen would have to be employed. If it were a non-union shop the best results could be obtained from foremen or assistant foremen or expert mechanics. In factories operating three or four types of machines, better results could be obtained by having one or two men from each department on the committee.

In fact, the general questions proposed in this article can only be answered after a thorough try-out of both carbon and high-speed steel by competent men, and a careful comparison of the data obtained from such a try-out. The object of such a try-out—the object of using high-speed steel—is chiefly to increase the output, which depends on the following factors.

A.—The tool.

1. Its construction.
2. Its composition.
3. The amount of material it must remove.
4. The hardness of the metal on which it must operate.
5. The finish required on the part.
6. The use or not of a cooling agent.
7. The cutting pressure on the tool.
8. The time it should last.
9. The number of tools to use simultaneously.

B.—The machine.

1. The speed combination to give at the same time the proper cutting speed and pressure required to take the cut.
2. The stiffness of the work.
3. Its fixtures, such as jigs, chucks, automatic magazine feeds, etc.

C.—The workman operating the machine.

1. His relations with his employer.
2. His desire to better his condition.
3. The stability of his employment.
4. The piece or day-rate system employed.

At the time of the introduction of high-speed steel, the tool and the part are immediately affected and become variables; the machine

Tool No.	Steel (brand)	TOOL CARD	Hardened by (Check No.)	Date
Temp. of furnace (°F)		Heat (Color)	Drawn to (°F)	Dept. (Drill, etc.)
Cooling agent (air, oil, etc.)		Type of Furnace (Cylindrical gas, etc.)		
Remarks (By Blacksmith)				

Name of part	No. of parts operated on	Check No. of Operator	Machine No.	Speed r.p.m.	Feed ft. per min.	Stock removed (Cubic amt.)	No. times ground	Remarks

Detachable.

Remarks: (By High Speed Steel Committeeman)

FIG. 1. "TOOL-CARD," FOR COLLECTING DATA CONCERNING THE USE OF HIGH-SPEED STEEL.

and the man operating it may or may not be ultimately changed, so they can be considered as constants. It is only necessary to keep data concerning the variables and their relations to the constants. Figures 1 and 2, which may be called the Tool and the Part Cards, respectively, give general data which should be of great value if properly obtained and interpreted.

The Tool Card should be attached to every new tool immediately after its completion, and should accompany it until it is worn out and ready to be sent to the committee for examination.

Part & Order No.	PART CARD	Dept.

Box Numbers	Lot No.	Part Name
Operation name & No.		
Workman's Check No.	Machine No.	Quantity operated on
Date	Rate per 100	Time per 100
Fixtures used		

Tool No.	Description (brand, etc.)
Carbon ground every	
High Speed ground every	

Finish	Gauge used	Speed r. p. m.	Feed ft. per min.	Cone feed	Lubricant

Depth of cut	Trial No.
Breadth	Name of operator
Width	
Length	Signed ____ H. S. S. Committee
Cubic amt.	

Piece Rate Pricing		Actual working time per lot	
Trial by		Allow for setting up per lot	
No. pieces machined		Allow for per lot	
Actual working time required		Total time required per lot	
Basis rate per hour		Pieces per hr. including allowances	
Machined in lots of		Piece rate (per 100) should be	

(Detachable)

Remarks:-

(Recommendations of High Speed Steel Committeeman as to the adaptability of a part to a machine, etc.)

Signed: ____ (H. S. S. Committee)

FIG. 2. "PART CARD," FOR COLLECTING DATA CONCERNING THE USE OF HIGH-SPEED STEEL.

No record is necessary of the construction of the tool except its cost and production. As this is kept in most cases by the system in vogue in any factory it is needless to provide a new one for it. For this reason, the plan proposed is applicable to any factory, whether it makes its own tools or buys them ready made. A number should be stamped on each tool either by the tool-maker or the blacksmith, and letters indicating its brand of steel. Some tool rooms turn out a number of similar tools in a lot. It is essential, no matter how many are turned out at a time, to keep an individual card with each one. The moment

Part & Order No.	INSTRUCTION CARD	Dept.
Box Numbers		Part Name
Operation name & number		
Fixtures to use		
Machine to use		

Finish	Gauge	Speed of tool r.p. m.	Feed ft. per min.	Cone feed	Lubricant

Output per hour including allowances

Grind tool

Signed: _____

FIG. 3. INSTRUCTION CARD. TO ACCOMPANY PARTS TO EACH NEW OPERATION WITH HIGH-SPEED STEEL TOOLS.

accuracy is overlooked the results become guess-work and are worth nothing.

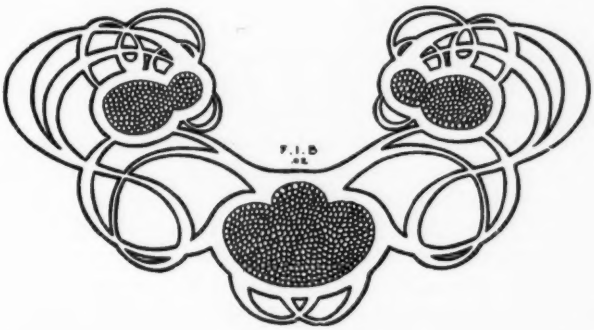
As soon as another tool of the same kind comes in for hardening the blacksmith should heat it not so hot as, or hotter than, the tool previously hardened. After he has hardened a few tools thus he will be able, by comparison and by consulting the record cards of the life of these tools, to find the best conditions of hardening them.

The Part Card is necessary only when a try-out is to be made and should be placed with the parts as they are charged out to each operation. The next problem after acquiring the data on cards 1 and 2 is to use it most efficiently. The workman and the blacksmith must be instructed by the committee. The Tool Card gives ample information for the blacksmith, and should be sent to him with the worn-out tool after it has been compared with the Part Cards by the committee. The foremen and the workmen must also be instructed. The method of doing this is simply a reversion of the data-acquiring process. In this the Part Card has reached the high-speed-steel committeeman, i. e., the "try-out man," in a blank form. After it has been filled out by him, certain data from it and from the Tool Card should

be placed on a card which should accompany the part each time it is charged out to an operation. This card might be called the Instruction Card, and contain data such as shown in Figure 3. Such a card is now used in many factories. It should be attached to the piece-work or day-work tickets that customarily accompany a part to each operator. This should be done repeatedly until a new try-out is deemed necessary. The responsibility is fixed in this case, and the workman has no excuse for spoiling a part or tool, or racking a machine by a too rapid speed, and he has a mark set without guess-work which is an index as to what should be his output. Such an instruction card is in fact an insurance to both employee and employer.

The average factory employee who has had much experience with systems of any kind has generally a horror of them. It is no wonder that this is the case in many factories which are literally buried under systems—for this is an era of systems. On the face of it, the task of keeping track of all tools and parts as proposed here might seem too great to pay for the results. As a matter of fact, it takes so long to make new tools that the introduction of high-speed steel is by necessity a comparatively slow process, and a few men should have no difficulty, if try-outs last no longer than an hour, in keeping pace with the output of the tool room of the average factory.

As no process discovered in recent years has effected such an increase of manufacturing capacity and such a general revolution in machine design, as high-speed steel, it is by necessity worthy of most careful study by the wide-awake manufacturer, who cannot fail to see the advantages of fixing the responsibilities of its introduction into the factory upon a carefully selected body of trained men.



HIGH-SPEED ELECTRIC INTERURBAN SYSTEMS FOR FREIGHT AND PASSENGERS.

By Ralph Scott.

The functions of electric traction, with reference to steam, appear to be generally of two kinds:—first, under certain somewhat limited conditions, to replace the locomotive in handling existing traffic; second, to build up a different kind of transport service, for which steam is not adapted. The systems described by Mr. Scott in the following article exhibit, in part, both these characteristics, and are interesting examples of a vast possible development.—The Editors.

At the present time, there are in successful operation in the anthracite coal region of Pennsylvania, two similar systems of electric railways which are built in accordance with the best modern steam-railroad practice, and which are conspicuous examples of the adaptability of electric roads for high-speed freight and passenger service. These systems are the Wilkes-Barre and Hazleton Railway, connecting Wilkes-Barre and Hazleton, and the Lackawanna and Wyoming Valley Railroad, connecting Wilkes-Barre and Scranton, with an extension to Carbondale.

On account of the difficult engineering problems which have been encountered, and their successful solution, these roads will, it seems safe to say, establish a precedent for the installation of a number of similar systems. The series alternating railway motor may also owe its first extensive application to one of these roads. A continuation of the principles which these roads have adopted would cause an epoch of heavy electrical railroading that would cause all the electrical work that has been done up to the present time to pale into utter insignificance.

It has been shown that a double-track third-rail system possesses great economic, flexible, and accelerative transportation facilities. The daily performance of these roads has shown also that small freight-carrying units, operating at high speed, are not subject to many of the limitations to which steam roads (even when equipped with up-to-date signal systems and other means for safe and rapid locomotion) are liable. Among the principal of these limitations may be mentioned:—

1.—The extra work necessary in shifting cars which are destined for various stations, and the delay consequent on classifying according to destination.

2.—Cumbersome methods employed in the handling of large amounts of freight.

3.—Frequent repairs to the track and rolling stock necessitated by the wear and tear on both by the movement, coupling, and shifting of heavy trains.

4.—Liability of a small breakdown delaying or destroying an entire train.

5.—Impracticability of moving long trains at high speeds.

6.—Increased weight of rolling stock, massive construction being necessary to minimize probability of breakdown while shifting cars and starting up long trains.

7.—Relatively low economy resultant on using a number of steam-generating units, each having a questionable efficiency.

Early electric-railway systems, and in fact recent electric yard locomotives, with but few exceptions, contemplated the concentration of the motive power in a single unit. These installations applied directly the practice common in steam locomotion, namely, the employment of a dummy with the requisite power, without consideration of the fact that the latter not only translated the heat energy of the steam into motive power, but also generated it. The means employed in the process of generation and translation, also, fortunately, gave the necessary weight to produce a ratio of adhesion which was consistent with the tractive effort. However, on account of the small weight of the electric motor per unit of tractive effort, after giving the proper speed reduction, the ratio of adhesion was entirely too low to be practicable. Hence the necessity of additional dead weight to give the electric dummy the required adhesion ratio for the hauling of a weight which would meet the requirements of economy.

The use of a relatively small number of units capable of developing a heavy torque, whether the motive power be electricity or steam, is advantageous from many points of view. The first cost of motor-driven freight units, if their number be sufficient to carry all the freight of an ordinary steam road, would be very great. By using the locomotive principle, with either steam or electric units, and hauling the heaviest freight in long trains, at times when the passenger traffic is least—that is, during the night—the cost of freight transportation is reduced to a minimum. Both of these roads have adopted this practice, the greater part of the heaviest freight being hauled dur-

TWO VIEWS ON THE LINE OF THE WILKES-BARRE & HAZLETON ELECTRIC RAILWAY.
The upper one is "Walp's Farm" fill; the lower is in the Conyngham Mountains.

ing the night by steam locomotives. An increase in freight traffic would so multiply the number of steam units that the most feasible and economical solution would be the employment of electrically-driven units.

A successful system of heavy railroading signifies the fulfilment of a number of specific conditions. Among these conditions are:—

economy and reliability of operation; a simple and reliable controlling system; high torque; and good speed acceleration of the motive elements. The low starting torque of the steam locomotive is well-known. If the cut-off be increased to maintain as nearly as possible a uniformly high mean effective pressure it is found impossible to keep the firebox contents in their proper condition, on account of the vacuum produced by the exhaust. The high factor of depreciation of powerful locomotives also militates against an increase in average output beyond a certain critical point. Improvements have been sought after along the lines of high piston speed, high boiler pressure, and multiple expansion, all of which are achieved with a high factor of depreciation and repairs due to the multiplicity of parts; and many railroad managers are conversant with the fact that the recent advances in the size and output have not been warranted by any resultant economy.

The construction of present steam-road freight-carrying units precludes the application of motors to each; hence, an entirely distinct set of cars is necessary for use as multiple freight-carrying units.

The fact that there is equal economy in freight transportation on both steam and electric roads would not conclusively argue for the general adoption of the latter system, nor would such a deduction form a basis for the subsequent universal relegation or revision of engineering tactics which would cause existing steam roads to assume a state of decrepitude; but the fact that the overwhelming advantages of electric traction, as utilized by these roads, are apparent from every side, renders such a conclusion self-evident.

Long trains, which are advantageous from a protective and time-interval standpoint, may, by the adoption of the multiple-unit system of control, be readily moved expeditiously, since the same power is taken by each car in the train as would be taken were it operating independently. The tractive effort, as a whole, is thus increased with an increase in train length, the only limitation to the number of cars employed being the current which the third rail is capable of delivering without excessive drop or line loss.

As stated before, it is not incumbent to use exclusively electrically-driven units in such a system. Locomotives are as applicable to train movement as are the motor-driven units—in fact, both may operate simultaneously. A breakdown in the generating or translating equipment in such a system (although of but remote possibility, yet worthy of consideration), does not assume the important phase that such a state of affairs would cause were the electric system alone used. It is only

by coincident operation, on a basis of equal advantage, that the relative adaptability of steam or electrically-driven or hauled conveyances to transportation can be ascertained. A direct line of argument, of adequate parallel, is thus assured for the exponents of each system.

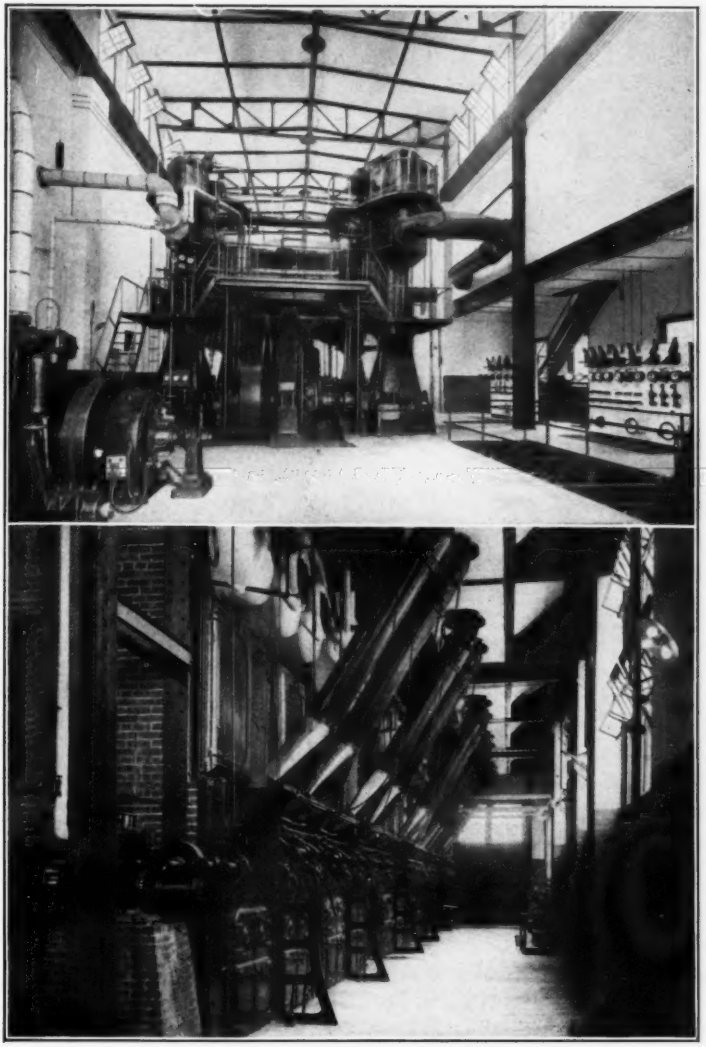
Both roads of which this article deals have the very highest standard of excellence in equipment and construction, and are equally capable of handling an enormous volume of business. Being interurban, they are able not only to handle the business between the cities which they connect, but are also the means of inciting and directing otherwise inactive suburban business into a profitable channel. The extension of such roads, using rural combination freight and passenger stations for concentrating purposes, will provide an outlet for an enormous amount of traffic that could in no other way be accomplished.

The ease of starting and stopping a motor-driven car renders possible a high average speed, even with frequent stops. Such cannot be said of local steam trains, on account of the great loss of time incident on such stops.

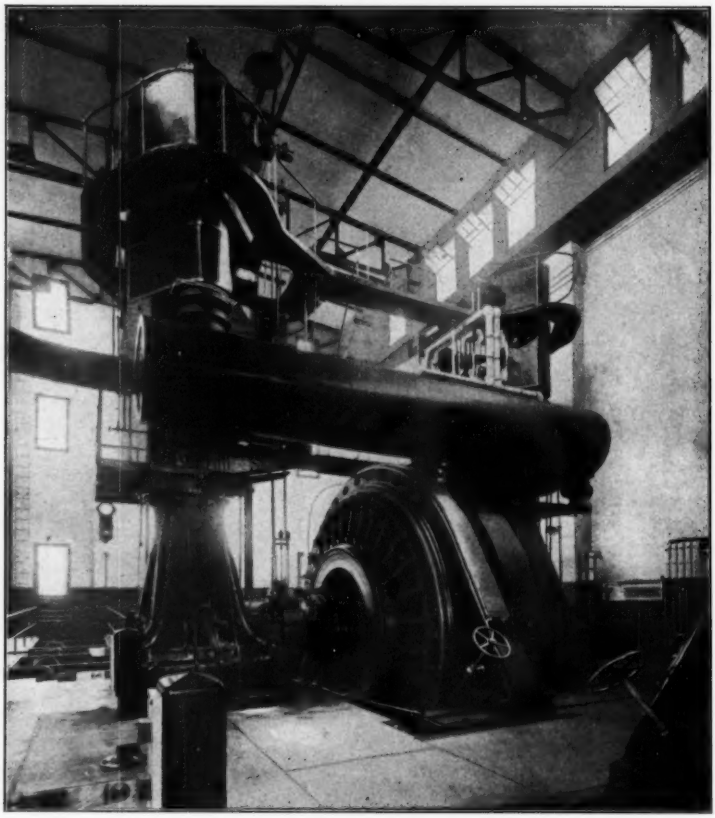
Where the freight and passenger service is uniform, it is advantageous to combine both freight and passenger cars in single units. This plan has been adopted by both roads, and their experience has shown it to be the most practical solution. The passenger compartment, which is separated from the freight compartment, is capable of seating forty or fifty persons without crowding. In the freight compartment are adjustable seats for about twelve persons, these seats being out of the way when freight only is carried. The latter part is 12 feet 9 inches long, and is provided with sliding doors for convenience in handling the freight.

The terminal facilities of these roads are on an equal basis with up-to-date steam railroads. Express service on the latter is no quicker than ordinary freight carrying on the electric system, because of the fact that on these roads all merchandise is handled without classification as to the time consumed in transportation. Thus 100 bushels of apples would be carried with no greater consumption of time in transit than would be required for a book of poems. The following is a brief description of the Lackawanna and Wyoming Valley R. R.:

The right of way includes about 40 miles of double-track railway. The road from Scranton to Carbondale is about 17 miles long, from Scranton to Wilkes-Barre 19 miles, with a proposed extension to Nanticoke of about 8 miles, which is to be completed in the near future. The power house, situated at Scranton, is of rectangular form, 90



ENGINE AND BOILER ROOMS, POWER PLANT OF THE LACKAWANNA & WYOMING VALLEY RAILROAD.



ONE OF THE GENERATING UNITS, POWER HOUSE OF THE LACKAWANNA & WYOMING VALLEY RAILROAD.

feet by 134 feet, the central part, above the generating units, being 42 feet high. The boiler room is separated from the engine room by a thick brick wall, being 42 feet wide and 26½ feet high. Installed within the boiler room are five Babcock & Wilcox boilers of the water-tube type, the normal capacity of each being 400 horse power, and each being capable of being forced to 600 horse power continuously. The working pressure is 160 pounds. These boilers are supplied with coal by Roney mechanical stokers, driven by a small Westinghouse standard engine. The stokers are fed from a coal bunker placed above and in front of the boilers, this bunker being kept filled by a motor-

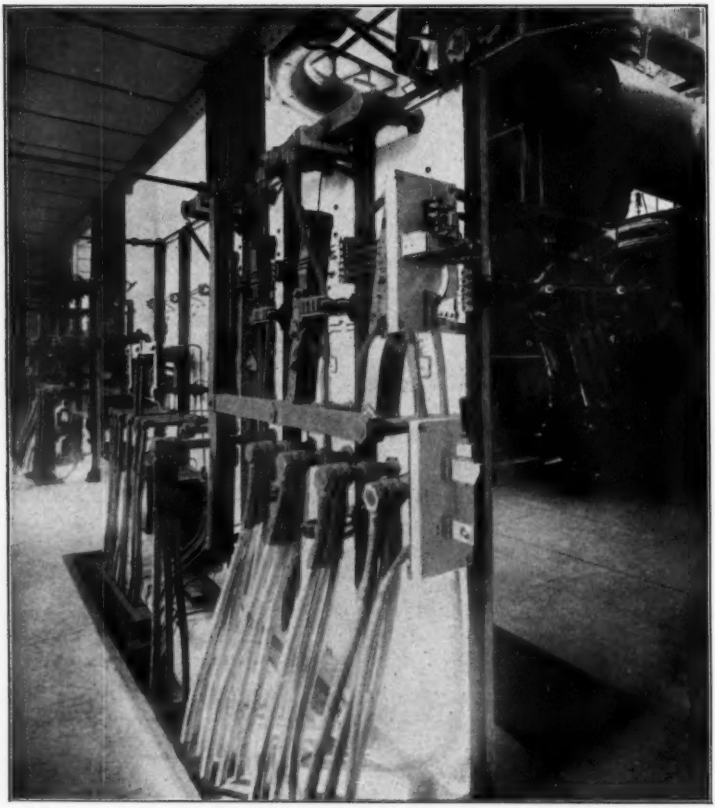
driven belt conveyor taking coal from a hopper beneath the railroad siding adjacent to the boiler room. Ashes are disposed of by a car (running beneath the boilers on a small track) into which the contents of the ash hoppers are discharged from time to time. Combination forced and natural draft is used, the blowers being directly connected to standard engines. Natural draught is supplied by a chimney 118 feet high and about 10 feet internal diameter.

A small stream, adjacent to the power house, with the city mains, furnishes the water necessary for condensing purposes, the intake well being located at the side of a reservoir formed from this stream. The main engines are disconnected from the condensing system by gate valves, when not in operation, these valves being controlled from the engine platforms.

The engines are of the Westinghouse-Corliss cross-compound vertical type, each of 2,000 indicated horse power, at 94 revolutions, with a capacity of 60 per cent. overload when run condensing and with a slightly increased initial pressure. The stroke is 48 inches, the high- and low-pressure cylinders being respectively 30 and 60 inches in diameter. Connected to the speed-regulating gear of each engine is a motor, operated from the switchboard, which changes the cut-off by adding weight to or taking it away from the governor spindle, this being effected through the interposition of suitable gears and levers. The purpose of this motor is to synchronize the engines when it is desired to run the units in parallel. The means for indicating the moment of synchronism are synchronizers on the switchboard, which, by the motion of a pointer over a dial, indicate which generator is running fast or slow. Since the generators are of the double-current type, this matter is very important.

The generators are of 1,250-kilowatt capacity each, the direct-current side discharging current at 650 volts into the Scranton end of the third rail, and the alternating-current side discharging current at 390 volts into the static converters, the secondaries of which are connected to the transmission line. The two exciter units, of 65 kilowatts each, are separately capable of furnishing the field current for both generators at full load, and are, consequently, operated intermittently.

Separate switchboards are provided for the direct- and alternating-current sides, the equipment of these boards being the usual standard apparatus for heavy work. The alternating current is handled at low voltage, before passing to the transmission line. Four 800-kilowatt transformers are used in translating the low-tension current into the high-tension current required for the line. These transformers are



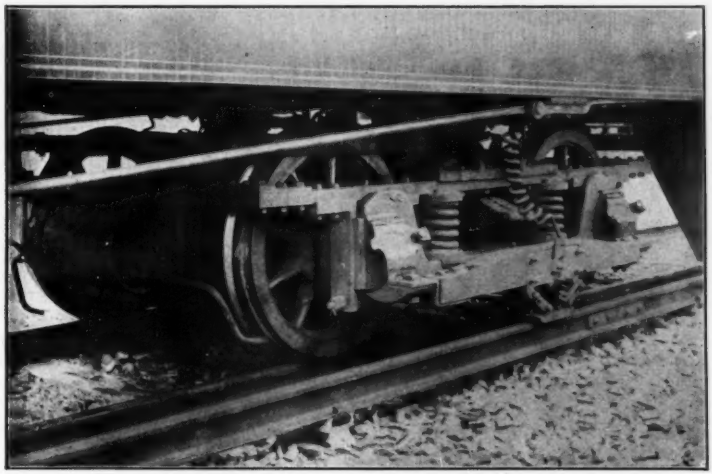
REAR OF DIRECT-CURRENT SWITCHBOARD, POWER STATION OF LACKAWANNA & WYOMING VALLEY RAILROAD.
The alternating-current switchboard is seen in the background.

placed beneath the engine-room floor at the opening shown in the latter, this opening being provided for the purpose of facilitating repairs, etc., by allowing the traveling crane to be used. Receiving three-phase (delta connection) current at 390 volts, they transform it into the 22,000-volt line current. Between the transformers and the line are the bayonet switches, by means of which any transformer may be disconnected. From here current passes through the static interrupters, to the line.

The static interrupters, which are illustrated, consist of a condenser connected between the lines and ground (this connection being

on the side of the apparatus to be protected), and a choke coil connected in series with the line, the free end of the coil being connected to the condenser. The coil and condenser are placed in a self-cooling wrought-iron casing filled with insulating oil, the oil being necessary on account of the high voltage used, and also to radiate the heat generated. The coils are very heavily insulated, being intended to withstand static discharges. The condenser consists of a number of sheets of rounded rectangular copper, between which are interposed insulating sheets, the alternate copper sheets being connected to the line and ground respectively. One static interrupter is used for each line wire.

The line wires are of No. 4, B. & S., bare copper, suspended on umbrella-type glass insulators arranged in an equilateral triangle on poles 100 feet apart. This line passes to the sub-station at Plains, some 14 miles distant. The line enters the high-tension tower at this sub-station, which also serves as a passenger station, and connects with fuse switches, static interrupters, and low-equivalent lightning arresters.



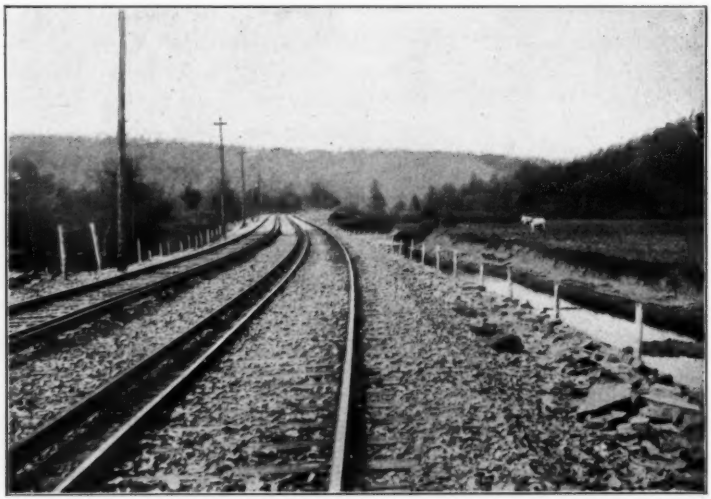
MOTOR TRUCK, CARS OF THE LACKAWANNA & WYOMING VALLEY RAILROAD.

Connection is then made to two banks of static converters which reduce the tension to 390 volts, at which pressure it enters the two 400-kilowatt rotary converters and is converted into direct current at 650 volts for the third rail at this point.

As stated before, the very highest standard of steam-railroad practice had to be followed, to fulfil the original design of the owners,

which called for high-speed service and heavy freight traffic. Speeds of 50 miles an hour are of regular occurence, and the time-table schedule of all trains between Scranton and Wilkes-Barre is about 30 minutes, including many stops.

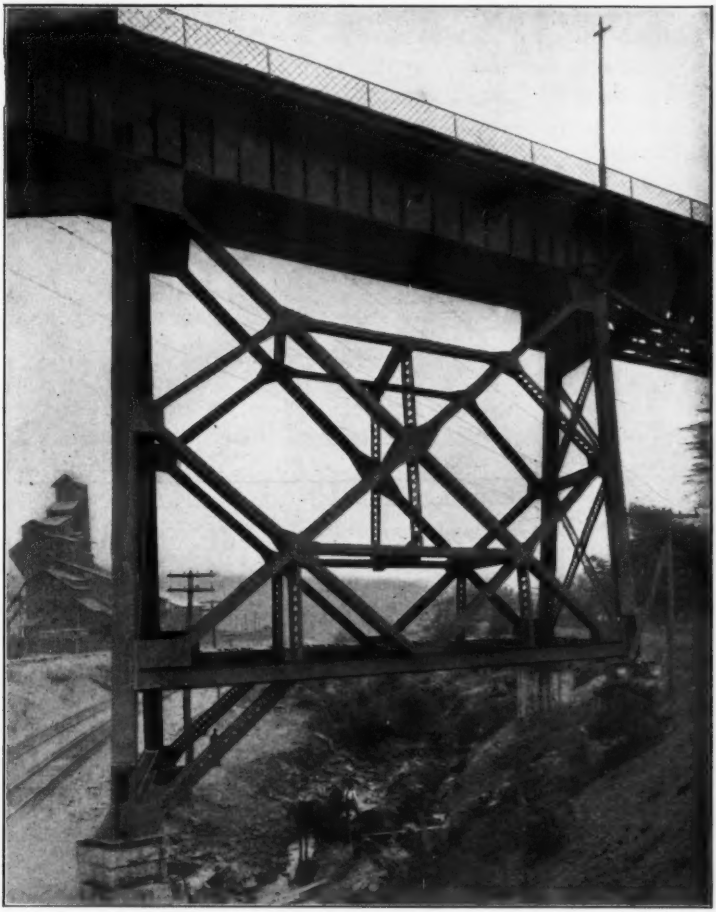
The main line between Scranton and Wilkes-Barre is of 90-pound A rail, and that between Scranton and Carbondale, 75-pound A rail. Guard rails and braces are provided at all curves, cross rail bonds being provided at frequent intervals. The ties are spread 2 feet apart, every fifth tie being longer, and carrying an insulator of artificial granite for the third rail. This latter is a 75-pound A rail, the separate rails being bonded with a heavy flexible bond placed beneath the web.



A PORTION OF THE ROAD BETWEEN SCRANTON AND MOOSIC, LACKAWANNA & WYOMING VALLEY RAILROAD.

The right of way is fenced off along the entire route by a galvanized-iron wire fence. All grade crossings are protected with cattle guards, the continuity of the third rail being broken.

Scarcely any of the grades are greater than 2 per cent. The almost entire absence of curves has called for a number of heavy engineering feats, such as but few steam roads of the same length have encountered. Another reason for this work is the great competition which exists, owing to the fact that a number of coincident and well-established steam roads are in the same territory. Securing a permanent way of such solidity in a region thus covered is of itself a triumph in engineer-



DETAIL OF THE AVOCA VIADUCT, LACKAWANNA & WYOMING VALLEY RAILROAD.

ing. It was of the opinion of many engineers that a location like that accomplished was an impossibility.

In many cases where the road crosses public highways, railroads, or streams, steel bridges are built, these being supported on concrete or stone abutments of massive character. The longest of these is the Avoca viaduct, which is 680 feet long and crosses the tracks of the Lehigh Valley R. R., Delaware and Hudson R. R., and the Scranton Traction Company's lines. This viaduct is composed of eight spans,

seven of these being formed of plate girders. Roller bearings are provided at all points where expansion is expected. In approaching Wilkes-Barre, there is another viaduct 554 feet long which crosses the Wilkes-Barre Traction Company's lines and the Lehigh Valley R. R.: about 800 tons of steel were used in the construction of this viaduct. South of this viaduct is an embankment for about ¼ mile along the bank of the Susquehanna River.

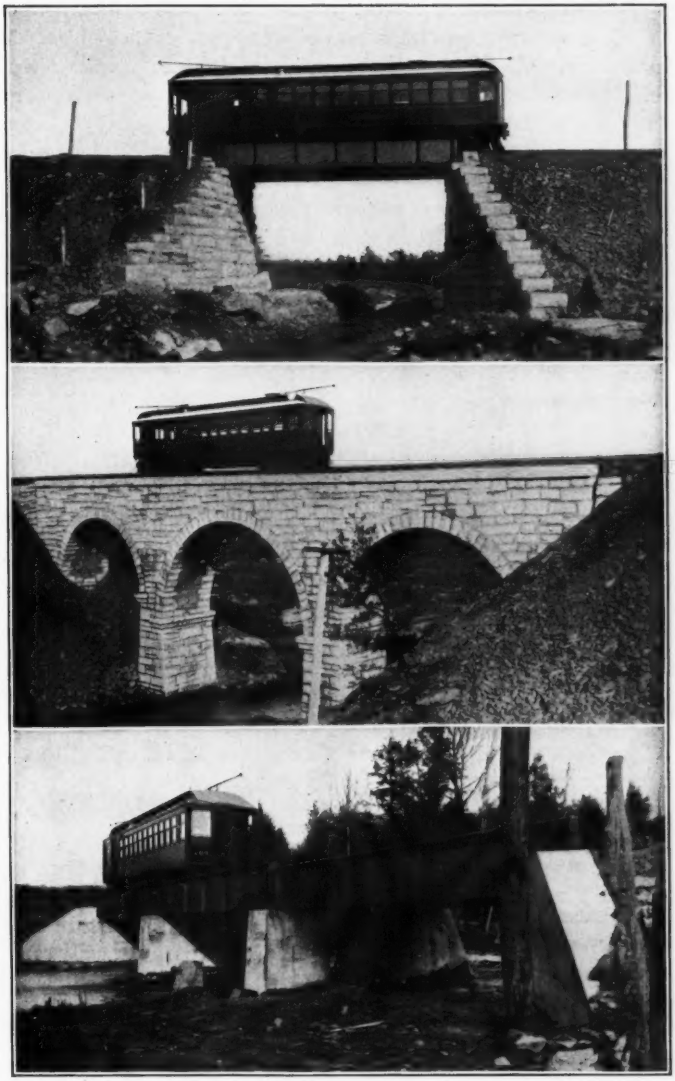
The rolling stock is designed for high-speed purposes, and is, consequently, of very heavy construction. M. C. B. equalized swing-motion bolster-type trucks are used, the rear truck carrying, on Gibbs suspension, two single-reduction motors, of 150 horse power each. Cast-steel wheels with steel wires are used. Each car is provided with motor-driven air compressors and automatic air brakes.

The equipment of the Wilkes-Barre and Hazleton Railway, although not as extensive as the one above described, is of the same high order of construction. The power house, which is located at St. Johns, about nineteen miles from Wilkes-Barre, is a rectangular structure of brick, and forms both engine and boiler house.

The generating equipment consists of three 400-kilowatt, 390-volt, 3,000-alternation, revolving-field, three-phase, Westinghouse alternating-current generators running at 115 R. P. M. The field current is furnished by two direct-connected 25-kilowatt, 125-volt, direct-current generators, driven by Harrisburg piston-valve engines at 300 revolutions. Each exciter is capable of supplying the field current for two of the alternators.

The alternators are driven by Fitchburg simple, horizontal, cross-connected 36 by 18 inch engines. Both cylinders are controlled by the same governor and valve gear, and either may be operated independently in case of light load. Each engine is fitted with an adjustable weight on the governor spindle, the leverage of this weight being changed through the medium of a threaded rod, which passes through the weight, by a small motor having suitable speed-reducing gearing. The engines are also fitted (both cylinders) with an automatic engine stop, which operates at ten revolutions above the normal speed. This stop consists of a centrifugal circuit closer, belted to the crank shaft and controlling the circuit of an electro-magnet. The armature of this electro-magnet, on being attracted, allows a weight to fall, thus releasing the valve trips and shutting steam from the engine.

The boiler room contains four 300-horse-power Heine safety tube boilers, operating at 135-pounds pressure, the feed water being supplied by two Deane double-acting pumps of the plunger type.



BRIDGES ON THE LINE OF THE WILKES-BARRE & HAZLETON RAILWAY.

At the top is a bridge over the Lehigh Valley tracks; in the middle, the stone arch bridge over Black Creek; at the bottom, the Wapwallopen bridge.

From the generators, current passes to six static transformers, arranged in two banks, two transformers being provided per phase (delta connection). The secondaries of these transformers are flexibly connected to bayonet switches, the fixed contacts of which are connected to the line on large triple-petticoat porcelain insulators. Interposed between the line and these switches are the reactance coils, condensers, low-equivalent lightning arresters, and fused switches.

The static transformers raise the pressure of the current to 15,000 volts. The line wire is No. 4 B. & S. bare wire, the conductors being arranged equilaterally on umbrella-type insulators. Arranged on the poles along the entire route is a telephone circut, to which, in cases of emergency, connection may be made with a portable set every 1/3 mile. A rotary transformer is provided at the generating plant to supply the third rail with direct current at this point.

From St. Johns the line passes to a sub-station at Nuangola, 13 miles distant. This sub-station contains a 400-kilowatt 500-revolution rotary converter and three static converters, the high-tension alternating current being translated into direct current at 625 volts for the third rail. On account of the increase in traffic, the transmission line is being extended from Nuangola to Ashley.

A portable sub-station, which may be used on any part of the road where the transmission line is at hand, is used when the traffic is very heavy. This sub-station consists of three static and rotary converters, with a switchboard, housed in a car of very heavy construction. Facilities for rapid connection to the third rail and line are provided, lightning arresters protecting against high-potential discharges.

The track is single, except where cars pass one another; the construction being similar to that of the system already described, the third rail being protected by a 2 by 5 inch timber placed 5 inches above the top surface of the rail, and supported by cylindrical porcelain insulators, placed on every fifth tie. Owing to the mountainous country traversed, the route is very circuitous and a number of heavy grades were encountered. Large cuts and fills were necessary along the entire route. About five miles from Wilkes-Barre a long tunnel was cut through Fairview Mountain, directly beneath the Lehigh Valley tracks.

The cars are of the same construction as those of the Lackawanna and Wyoming Valley, and are equipped with both hand and air brakes, the hand brake having a great leverage, and being used only in cases of emergency. The motorman's cab is placed at one side of the entrance cab, all working levers being arranged conveniently.

THE BIG STONE GAP COAL-FIELD OF VIRGINIA AND KENTUCKY.

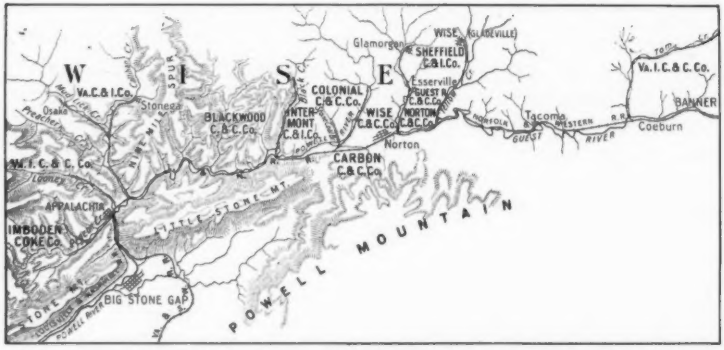
By John Leggett Pultz.

Mr. Fowler's account of the Pocahontas coal-field, which we published in May and June last, dealt with a region which is of importance because of its possible contribution to the steam fuels of the world. The coal measures described by Mr. Pultz in the following pages have a like interest, through the promise they give of rivalling the Connellsville seams in furnishing the great metallurgical fuel—coke.—THE EDITORS.

THE coal-field is located in the central portion of the Appalachian coal basin in southwestern Virginia and southeastern Kentucky. It is a long, narrow basin varying from 12 to 15 miles in width and extending in a northeast-and-southwest direction for a distance of about 36 miles. The field is approximately 540 square miles in area, and includes a deeply dissected region made up of ravines and steep ridges, which in the eastern portion of Wise County attain altitudes of over 4,000 feet above sea level.

The early settlers in this part of the country undoubtedly mined the coal on a small scale for domestic use, but the history of the field really began with the systematic extraction of the coal on a large and economic basis. In 1880, several wealthy mine owners in the anthracite field of Pennsylvania became interested in the Big Stone Gap Field. One of these gentlemen, a Mr. Leisenring, purchased a tract of land located in Wise County, Virginia, comprising 67,000 acres and afterwards held under the title of "The Virginia Coal and Iron Company." Strange to say, although Wise is today the largest coal-and coke-producing county in the State, still it was the last to be developed. Not until 1891 did railroads penetrate the field, and then the Clinch Valley Branch of the Norfolk & Western, and the Cumberland Valley Branch of the L. & N. Railway, were constructed with their terminals at Norton. The South Atlantic & Ohio, now the Virginia & Southwestern, has its terminal at Appalachia and gives this field an outlet to the southeastern markets. The completion of these roads gave the necessary outlet for the Wise County coal and coke, besides stimulating development work to such an extent that nine mines were soon in operation, and the total coal production for the ensuing year reached 124,088 short tons.

In 1895 the first coke was produced in the district by the Wise County Coal Company and the Big Stone Gap Colliery Company, while a third operation, known as the Virginia Coal & Iron Company, had a battery of ovens under construction. The Virginia Iron, Coal & Coke Company, one of the largest plants in the region, started on a small scale in 1896 under the name of the Tom's Creek Coal Company, which was later improved so extensively that the output of this mine alone was a strong factor in the increased annual coal and coke production of Wise County. At the close of 1896, there were 100 new ovens building at Stonega, which brought the number of ovens owned by the Virginia Coal & Iron Company up to 500 and made the total number in the district 834, all of which had been constructed within the short space of three years.

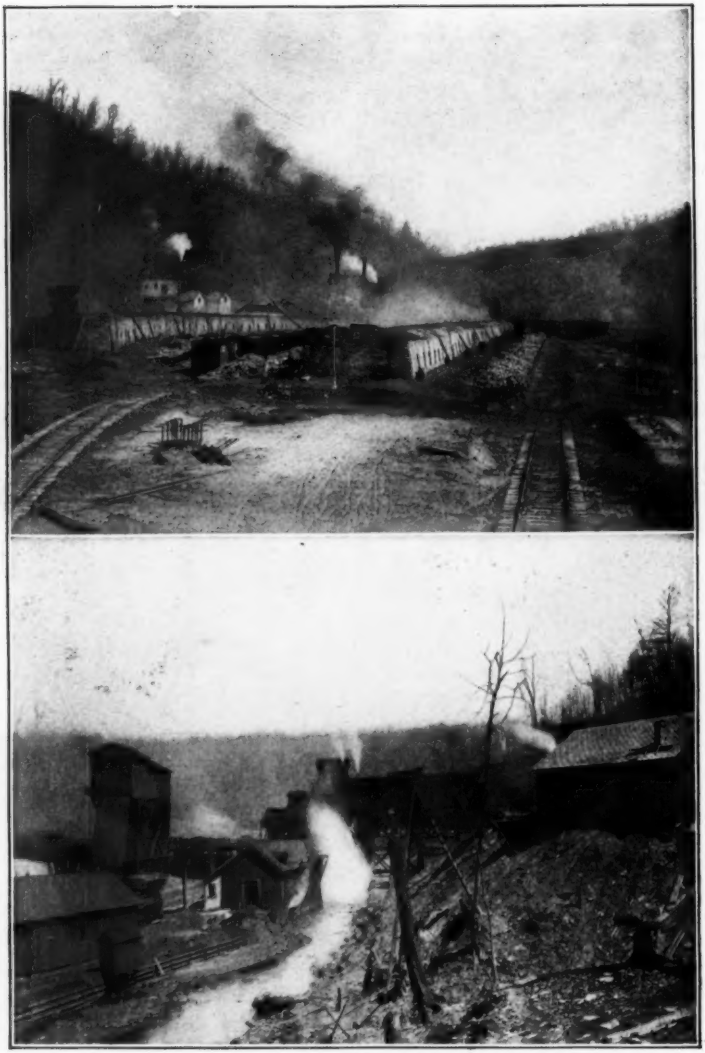


MAP SHOWING LOCATIONS OF THE COKE OPERATIONS IN THE BIG STONE GAP COAL-FIELD, WISE CO., VA.
Scale, 1 inch equals 6.5 miles, nearly.

Development work, once started, progressed with great rapidity. Since 1893 the annual coal production of Wise County has doubled three times, passing 1,000,000 short tons in 1899, 2,000,000 short tons in 1902, and at the close of 1903 this last yearly output has been increased to 2,563,000 short tons. In brief, at the end of the first ten years of the life of the region the coal production of the field was more than twenty times the output of the first year.

Tazewell and Wise are the only two important coal and coke-producing counties in Virginia. The output of Montgomery, Pulaski, and Chesterfield Counties together was only 36,823 short tons in 1902. The coal production for Wise County this same year reached 2,422,417 short tons, against 723,753 short tons in Tazewell. The coke produced in Wise County is made from coal mined

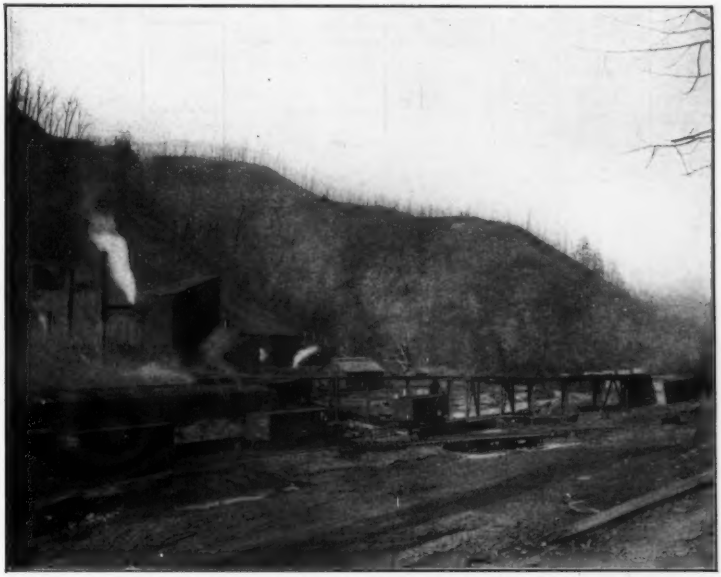
TWO OF THE OPERATIONS OF THE VIRGINIA IRON, COAL & COKE COMPANY.
The upper view is the Tom's Creek plant; the lower, the coke ovens at Inman, Va.



TWO VIEWS OF THE MINES, TIPPLES, AND OVENS OF THE VIRGINIA COAL & IRON CO., AT STONEGA, VA.

within the boundaries of the State, a fact that applies to no other county. At the present time, there are 3,414 ovens in the district, which produced 80 per cent. of the Virginia coke output.

Having roughly followed the growth of this field from its early history up to the close of 1903, it remains for me to describe briefly the geologic conditions existing in the basin and to discuss in some detail the occurrence of the workable seams.



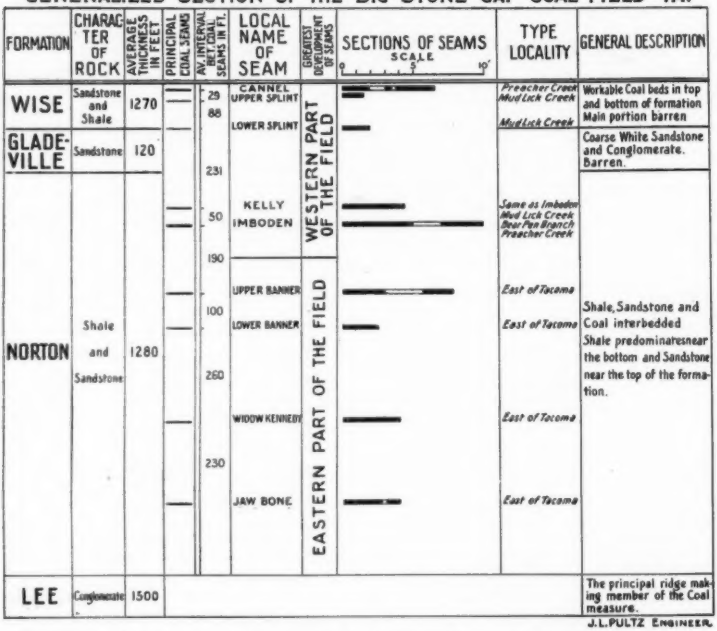
THE COLONIAL COAL & COKE CO., DORCHESTER, VA.

The small cross mark on the ridge indicates the position of the 8 to 10 foot seam shown in Mr. Esser's section, measured at Dorchester, referred to on page 79.

Big Stone Gap is a deep gorge cut by Powell River through the sharply folded formations of the Carboniferous, comprising the bulk of Stone Mountain, a northeast-and-southwest ridge, the southeastern portion of which carries Devonian beds rising abruptly from the wide valley in the Silurian measures to the south. This gap has been of great economic value in the development of the field, for it has enabled the Virginia & Southwestern and the Louisville & Nashville Railroads to construct their lines along Powell River, and to send short spurs northward up the many tributaries into the heart of the coal measures.

Seven distinct formations have been recognized in the Carboni-

GENERALIZED SECTION OF THE BIG STONE GAP COAL FIELD VA.



ferous of this field. The mean thickness of each formation is given in the following section:[1]

Name of Formation.		Mean Thickness in Ft.
Harlan	Sandstone	880
Wise	Formation	1,270
Gladeville	Sandstone	100
Norton	Formation	1,280
Lee	Conglomerate	1,500
Pennington	Shales	1,100
Newman	Limestone	930
Total thickness		7,060 feet.

The Norton is the most important formation of the series, for it carries the greatest number of workable seams. It is exposed continuously in the valley extending along the northern escarpment of Stone and Powell Mountains, and to the north in ravines cut by the tributaries of Powell River. The Gladeville sandstone is shown on the

[1] Bulletin III., U. S. Geol. Surv.

geologic map by a thin irregular band separating the Norton from the Wise formation which forms the highlands to the north. The Harlan sandstone is exposed in the high ridges in the western part of the field, while the two lowest formations outcrop over the greater portion of the territory lying to the south.

As a method of expressing concisely the relative positions of the principal coal seams occurring in the field, I have made a generalized geological section. See the opposite page.

Much confusion has arisen in correlating the seams outcropping in the ravines of the numerous local and somewhat disconnected basins. The prospector in most cases identifies a seam principally by its height above water, and ignores minor structural features, such as the numerous gentle folds, a detailed study of which only can definitely determine the positions of the different seams.

The coal beds of economic value range from 3½ to 12 feet or more in thickness, but a parting of several feet usually occurs in the thicker beds, such as the Imboden, making the total of the two benches at least 6 to 7 feet of clean coal. The generalized section shows eight workable coal horizons lying between the base of the Wise formation and a point 200 feet above the Lee Conglomerate, a distance of about 1,200 feet. The four highest seams, of which the Imboden and Kelly

LOONEY CREEK PLANT, VIRGINIA IRON, COAL & COKE CO.

PLANTS OF THE INTERMONT COAL & IRON CO.

The upper one is at Dooly, Va.; the lower is the Kelly & Irvin plant.

are the most important, reach their greatest development in the western portion of the field, while the lower four occur above water in the region to the east. The intervals between the seams vary greatly in the different parts of the field; I regret that this cannot be shown more clearly in the generalized section. Mr. John Esser gives the following section measured on the Colonial Coal & Coke Company's property at Dorchester. The section will illustrate the positions of the various seams in the central part of the field. The top seam lies in the ridge on the western side of Powell River about a mile north of the plant. It has only lately been opened up and shows a fine exposure of 7½ feet of coal, but owing to the extremely high position of this seam in the hills it appears to have a limited acreage.

Coal.....	6—7 feet.		Occurs in the ridge at the head of Bear Branch, about one mile north of Dorchester.
30 feet Interval.			
Coal.....	2—2 feet 6 inches.		
65 feet Interval.			
Coal...	4 feet.	Top bench.	This is known locally as the "Double Vein."
	3 "	Sandstone.	
	4 "	Bottom bench.	
80 feet Interval.			
Coal.....	8—10 feet.		This seam has lately been opened at Dorchester.
15 feet Interval.			
Coal.....	3 feet 8 inches.		
45 feet Interval.			
Coal.....	2 feet 6 inches.		
300 feet Interval.			
Coal.....	2 feet.		
40 feet Interval.			
Coal.....	8 feet.		Big Dorchester seam worked by the Colonial Coal and Coke Co.
36 feet Interval.			
Coal.....	1 foot 6 inches.		In some places this seam is only 4 to 6 feet above the Gordon.
15 feet Interval.			
Coal.....	4 feet 10 inches.		Known locally as the Gordon seam. It is being worked at Norton, Wise, and Dorchester.
40 feet Interval.			
Coal.....	5 feet. 4 inches of parting.		Worked at Norton, Wise, and Dorchester.

The Imboden is the most important seam in the district. It is continuous over a large area, but unfortunately its horizon in the eastern part of the field has not been determined with any great degree of accuracy. M. R. Campbell speaks of its possible correlation with a seam known locally as the Edwards, which occurs in the vicinity of Tacoma. The Imboden varies considerably in thickness, and shows

AN ELECTRIC LOCOMOTIVE HAULING MINE CARS IN THE BIG STONE GAP FIELD.

excellent exposures on Bear Pen Branch and numerous other ravines in the western part of the field, where it is extensively worked by some of the largest plants in the region. The following section measured on Preacher Creek shows about the maximum thickness attained by this seam.

PIGEON CREEK PLANT, IMBODEN COKE COMPANY.

Sandstone Roof.	Feet.	Inches.
Coal	11	..
Bony Coal	..	3
Coal	1	8
Clay	..	2
Total	13 feet	1 inch.

There is but slight variation in the character of the more important coals in the district. The seams worked are bituminous and are classed among the high-grade coking coals. The physical properties of the Imboden seam are excellent, and it has a cubical structure formed by two well developed cleavage planes. The following comparative table gives the analyses of coal and coke in the Big Stone Gap and Connellsville Districts. The analyses of the Connellsville Coal and coke, taken from the XXII. Annual Report of the United States Geological Survey, are the averages of a considerable number of tests. The analysis of the Big Stone Gap coal is a fair representative of the Imboden seam, sampled on Looney Creek by McCreath, while the one of the coke is an average of a series of tests made over an extended period by the South Chicago Furnace Company on Imboden coke consigned to their plant in Chicago.

Big Stone Gap Field.	Coal.	Coke.	Connellsville Field.	Coal.	Coke.
Moisture	1.154	....	Moisture	....	0.184
Volatile Matter	35.346	1.48	Volatile Matter	31.04	.552
Fixed Carbon	60.107	87.91	Fixed Carbon	61.97	88.726
Ash	2.750	9.86	Ash	5.77	9.993
Sulphur	0.643	.74	Sulphur	1.22	.533
Phosphorus	.....	.01	Phosphorus	....	.010
Totals	100.000	100.00	Totals	100.00	99.998

Comparing the coals of the two districts, it will be seen the coal from the Virginia region is higher in volatile matter, somewhat lower in fixed carbon, and very much lower in ash than the Pennsylvania coal.

The analyses of the cokes show that there is a marked similarity between the corresponding constituents. As to physical properties, the coke made in the Big Stone Gap Field has an excellent cell structure, and the prevailing opinion among both furnace and foundry men is that it equals the Connellsville product.

As already stated, the ash content in the Imboden coal often runs very low, and in order to obtain a structurally strong coke, it is often found necessary to add a quantity of rash, occurring in the middle of

the seam, sufficient to bring the content in the coke up to 10 per cent. The coal is subjected to a preliminary crushing which reduces it to a size varying from 1 to 2 inches. This treatment serves to mix the coal and rash thoroughly and greatly facilitates the coking.

The mining operations in the regions are confined to the area lying north of Powell and Guest Rivers. No workable seams occur in Stone Mountain to the south. Table III gives the principal coke operations in Wise County, besides the location, number of ovens, and estimated coke output of each plant. Many of these operations, as the Virginia Coal & Coke Co., the Virginia Coal & Iron Co., and the Colonial Coal & Coke Co., also ship a large quantity of coal.

TABLE III

COKE OPERATIONS IN WISE COUNTY, VA.

Name.	Location of Operation.	Number of Ovens.	Estimated Requirements for Ovens in Tons. Coal: Daily	Estimated Output in Tons. Coke: Daily
Imboden Coke Co.	Pigeon Creek, Bear Pen Branch	289	875	578
Virginia Iron C. & Coke Co.	Looney Creek	168	500	336
Virginia Coal & Iron Co.	Osaka	350	1,000	700
" " "	Stonega	666	2,000	1,332
Blackwood C. & C. Co.	Blackwood	200	600	400
Intermont C. & I. Co.	Josephine	60	180	120
Carbon C. & C. Co.	Middle Norton	20	60	40
Colonial C. & C. Co.	Dorchester	450	1,350	900
Wise C. & C. Co. (Auxiliary plant of Colonial C. & C. Co.)	"	50	150	100
Norton C. & C. Co.	East Norton	110	330	220
Guest River C. & C. Co.	Esserville	51	150	102
Sheffield C. & I. Co.	Glamorgan	200	300	400
Virginia Iron C. & C. Co.	Toms Creek	800	2,500	1,600
		3,414	9,995	6,828

Although the structure of the region is somewhat complicated, the gentle character of the broad folding has only slightly tilted the coal seams and it is therefore possible to conduct mining operations under extremely favorable conditions.

The method of mining employed is the room-and-pillar system. The coal is generally attacked by parallel-face headings 8 and 9 feet wide, with a 50-foot pillar between them. These dimensions apply to 600 feet of covering. At intervals of 400 feet, cross headings are driven right and left and rooms 20 feet wide and 300 feet long are turned off in both directions, leaving 30-foot pillars. It is doubtful if

more than 75 per cent. of the coal was formerly recovered. Recently, however, there has been much improvement in the methods of mining, and under favorable conditions this figure should be raised largely.

Ventilating furnaces are in use at the majority of the mines, but when the workings begin to assume large proportions the necessary ventilation is produced by means of exhaust fans.

Underground haulage is accomplished by mules and electric locomotives of the Baldwin, General Electric, and Jeffrey types, ranging in weight from 10 to 17 tons. When the workings are in a narrow spur, there is often a considerable outside haul between a series of drifts. In several localities, where the seams occur exceptionally high in the ridges, short inclines equipped with barneys are in use.

Tipples are erected at the terminal of the trolley roads connecting the different openings, and they are usually at a considerable elevation above the valley floor. Long chutes of 45-degrees gradient connect the tipples and bins, which have a capacity of at least one-day's output in order to insure against any delay in charging the coke ovens. In the most recent type of bins, the crusher is located directly beneath the screens in the chute and the fine coal is placed in the pockets by means of conveyors.

There is considerable difference in the power plants of the numerous operations; at a few of the older workings, electricity is not used at all. Up to the present time electricity has in most cases been applied only to haulage. The Norton Coal & Coke Co., however, is electrically equipped throughout, and is one of the few operations in the district mining coal with machines. A type of plant applying electricity to both the underground and surface haulage systems is shown in the view (page 80) of the Imboden Coal & Coke Co.'s mine on Pigeon Creek. This mine has been in successful operation since its completion a year ago and has a coal and coke output of about 900 and 600 tons respectively. The power-house equipment consists of two Atlas boilers of 150 horse-power each, and one McEwen engine rated at 275 horse power which is belted to a Jeffrey 150-kilowatt generator supplying a current of 250 volts.

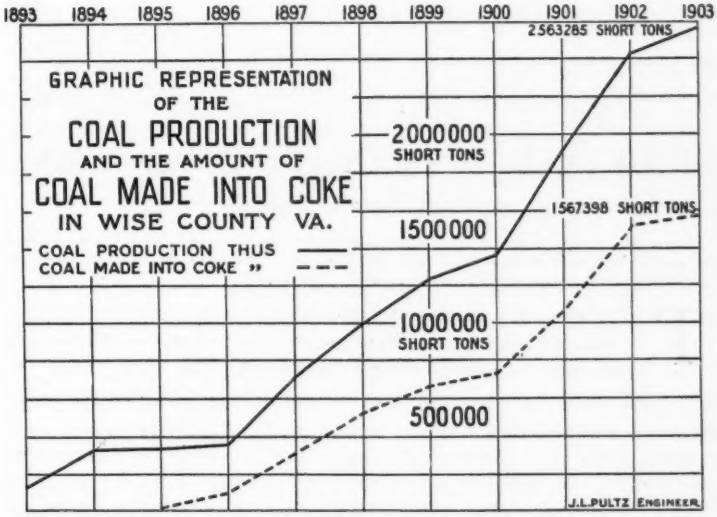
The Stedman type of crusher is in use at the greater number of operations. It is the general practice to run the crushers by steam. At the Norton Coal & Coke Co., electricity is employed for this purpose and has rendered efficient service without serious mishap for a considerable period. The opinion seems to be that the fine coal dust will cause trouble, but at Norton this is avoided by a dust-proof casing.

The coke ovens are of the standard bee-hive type and are built mostly in double batteries, but several plants have single batteries of bank ovens. The latter style of oven has many disadvantages, foremost of which is an extremely poor draft which necessitates a longer coking period. The Minor brothers have built the greater number of ovens in the district. These ovens are of excellent construction and have a 12- or 12.5-foot floor and a 6-foot-6-inch crown. The doors are high and of sufficient size to allow exceptionally large charges, a fact that greatly influences the cost of coke when drawing is by contract. It is the custom to make 48-hour coke four days in the week, and to begin charging 72-hour coke on Saturday in order to avoid Sunday work. The quantity of coal charged to the ovens varies with the coking period. The first 48-hour charge is from 5.5 to 6.6 tons, and the second ranges between 6.6 and 7.5 tons, while the 72-hour coke requires 8 to 9 tons of coal.

The coke larries are of 7- and 8-ton capacity and have double discharge. In the smaller plants mule haulage is used, but in the larger operations steam and electricity are more efficient. Both the third-rail and trolley systems are in operation. The trolley applied to coke ovens has proven satisfactory, and the motor larries are of sufficient power to haul several trailers.

The market for the Big Stone Gap coke embraces a considerable area. The greater part of the product goes north, and the trade with points northeast of Cincinnati is growing rapidly. Several iron companies, such as the Virginia Iron, Coal & Coke Co., and the Sheffield Coal and Iron Co., owning plants at Inman and Glamorgan respectively, consume their own coke when their furnaces are in blast. The coke of this region can be made at a cost permitting it to enter into active competition with the high-grade products of other fields. The furnace and foundry coke can reach all the territory northwest of Columbus and Cleveland. There is a demand for coke for smelting and foundry purposes in Mexico and the southwest, and the Big Stone Gap Field seems capable of supplying this market. In ordinary times shipments are made to Gadsden and Sheffield, and under the most favorable market conditions as far south as Birmingham. At the present time about 1,000 tons per day of coke is being shipped to the T. C. I. & R. R. Co., Alabama Consolidated Iron Co., and other furnaces in the Alabama district.

The coal output of this region will increase greatly, but the excellent coking qualities of the coal will always make the field essentially a coke producer. Virginia and North Carolina are accessible, and



the seaboard can be reached at Norfolk where there are prospects for a large export trade. The Western coal market has not been exploited to any great extent, owing partly to the absorption of the coal output in the manufacture of coke. A large trade is being opened up in South Carolina, North Carolina, and Georgia, owing to favorable freight rates. It is said that the coals of this region can be marketed in any territory where the freight rate is not more than 30 cents higher than from the Tennessee mines. Where it comes in competition with the Pocahontas, Kanawha, New River, and Connellsville districts, the rates must be in favor of the Big Stone Gap field. The market for the coal of this region is much more limited than that for coke, but the territory to the south and east is capable of greatly increasing the present comparatively small output.

Admirable work has been done in the development of this region. Many of the operators are Pennsylvania men, and to their excellent training in the northern field is due the high economic efficiency of their operations, a fact that has given the Big Stone Gap Field the title of the "Southern Connellsville." This title is certainly earned, as this region yields a coke which is the most serious competitor, both as to physical and chemical qualities, which the Connellsville operators have to meet outside of their local market.

STEAM COSTS IN INDUSTRIAL COMBINATIONS.

By William D. Ennis.

While Mr. Ennis discusses his subject primarily from the standpoint of the manager of a number of associated plants, almost all his practical suggestions for determining steam costs apply well also to the individual factory.—THE EDITORS.

THE fallacy has long been exploded that the combination of two or more kindred industries posseses in itself any economic virtues from a manufacturing standpoint. The condition of industrial consolidation, like any other industrial condition, naturally presents lines of least resistance along which profitable policies evolve. Combinations offer characteristic opportunities, just as an independent and strictly competitive business naturally develops certain tendencies under competent management. Measuring value of opportunity by facility and completeness of achievement, it cannot be said that chances for economies under a system of industrial combination are of necessity any better than under independent organization.

This is especially true in connection with steam costs. A pound of coal is a pound of coal, and a British Thermal Unit has an invariable value, to the Steel Corporation or to the smallest tank shop. In one respect, however, a combined industry has a decided advantage—namely, in the possession of comparative data regarding the performance of similar plants. But such data can frequently be obtained by the independent, also; and even the possession of such data is of potential value only, the discrepancies between costs which are shown to exist depending rather upon the character of plant respectively possessed than upon radical difference in competency of management.

It is not the province of this article to discuss late developments in steam-generating and utilizing machinery. The assumed condition is that of a plant already equipped with boilers and engines of average grade, in which, without contemplating large expenditures for radical and thorough revision, the engineer is expected to reduce the cost of steam. Arguments for and against the use of superheat, turbines, electric driving, economizers, etc., are obviously out of place. The subject is rather those methods of organization and operation of existing

equipment in an integrated industry which have been found to reduce costs.

The head of the department should be a technically trained engineer—one having had previous experience in the industry which he is to serve, and thoroughly familiar with its power requirements and conditions. He should have advisory, though not absolute, jurisdiction of the plant superintendents, and should correspond with them and not with the plant engineers on matters pertaining to the steam departments of the various mills. Otherwise there is a division of responsibility for the economical conduct of mill operation. Reports covering the performance of the steam department at each mill should be made by the superintendent from information received from the mill engineer. The engineer in charge of the steam department should spend a large portion of his time at the mills, and when thus locally visiting should be expected to confer informally with the mill engineers, making suggestions and giving directions that could be thus better carried out than by filtration through the non-mechanical mill superintendent. He must consequently be a man of considerable tact and force of character; and, as much of the control of the cost of operation of his department is in the hands of an official who is not wholly and directly responsible to him, he should have the faculty of getting along with men pleasantly and profitably, and of accomplishing much by that form of suggestion which is the equivalent of a command, and by a memory which never blots out the record of things undone which should be done.

In computing the cost of steam, the following expenditures should be included:—

Coal or other fuels
Engineers
Firemen
Laborers
Mechanics
Lubricating oils, used on engine-room machinery
Waste
Water
Supplies, subdivided if necessary
Engine and boiler repairs

Should any of the above be applied to other purposes than the production of steam, a proper credit should be made to the steam account. For instance, if the chief mill engineer is also the head mechanic, the general repair account of the plant should be charged with its propor-

tion of his time. If water is used for other than boiler-room purposes, as for various manufacturing operations, the steam department should not stand the entire water bill.

In an industry composed of large plants (say 3,000 horse power and over) it would probably be advisable to separate the disbursements completely into the ten classifications above given, with additional subdivision of expenditures for supplies, if necessary. In small plants (1,000 horse power), the four steam accounts—fuel, labor, repairs, and supplies may be sufficient.

The chief mill engineer should have general jurisdiction over all repairs to the mechanical plant—shafting, belting, electrical equipment, lighting, wiring, pumps, etc., for upon the good condition of these the consumption and consequently the cost of steam to a considerable degree depends. In order that he may have time and opportunity to leave the engine-room so as to be free to supervise or personally conduct various repair jobs, he should be given an oiler, competent to have charge of the engine-room in operation with his chief within call. At other times this helper can be used in the fire-room and on repairs. The machine shop should be close to the engine room and separated from it by glass partitions, so that a man in either room is to all intents and purposes in both. The night engineer should be considerably lower paid, the day job to be always in his view a highly desirable promotion. In small plants he should do his own oiling and should have no engine-room assistant. Where an eight-hour or three-tour system is practised, for either engineers or firemen, it is frequently possible to work the fire-room and engine-room helpers on a ten or twelve-hour trick. In this, as in all other industrial organization, it is unquestionable that for good results there ought to exist the widest possible distinction between the commonplace and the capable employee. The reward for efficiency should be made sufficiently great to stimulate every man to do his best, and each man should be given to understand that promotion is as readily possible for him as for anyone, upon demonstration of superior capacity. Small rewards, parsimonious recognition of merit, make employees inert and indifferent. The rank and file should have the private's pay and privileges; but the man of genuine worth should be invited to demonstrate his value in unquestionable ways, and should understand that for high-grade service there is a reward correspondingly high within his reach. There should be no levelling tendency in business.

The mill engineer, for the wages usually paid in such positions, will not be a technically trained man He should be a thorough economical

mechanic, experienced in the machine shop and fire-room, with good horse sense about questions of safety and strength, and sane notions on matters of combustion and engine economy. He should have absolute control of the personnel of his department, and must therefore be a man of executive ability within his field. He must be broad-minded enough to accept suggestions on modes of operation the philosophy of which he may not comprehend, and honest enough to execute intelligently what others may plan.

The selection of supplies for the use of the steam department should be based upon recommendations by the chief engineer of the company, who will derive his information partially, of course, from reports by the mill engineers. The actual purchasing should be left wholly under the care of the general purchasing department.

Various elaborate reports are used to enable the chief of the department to keep posted on the operation of each mill. But if the cost of coal per unit of product is as low as it has ever been, and as low as it is in any other plant, conditions considered, then the engineer had better devote his first attention to some other economy more immediately opportune than those which might be suggested by a closer analysis of the returns.

In nearly all cases, the cost of fuel constitutes more than half the cost of steam—sometimes, in very large plants, fuel amounts to nine-tenths of the total; and, if he fails everywhere else, the steam man who can reduce the cost of fuel will probably show an economical result in the operation of his department. This cost depends upon the following factors: the price of fuel per ton; the evaporation of water per pound of fuel; the consumption of steam per horse power of the engine units; and the amount of horse power used by the plant. With the first of these the mill engineer usually has little to do, his work being limited to the accurate comparison of the evaporative values of such coals as may be chosen for trial. The second and third factors are wholly under his control. The fourth is also, to a degree depending upon the man himself and the co-operation he may receive from other departments.

In order to have a complete general knowledge of the performance of the plant with respect to the three factors last named, the following data must be obtained:—

Fuel consumed
Water evaporated
Horse power developed
Product of the plant.

These can all be obtained, and should be obtained, with very little expense, for each day's operation. It is best, of course, to actually weigh the coal burned. This is less difficult than would appear at first sight. A barrow or car can be filled to the limit, the weight determined, and a record then kept of the number of times the barrow or car is emptied during the day. This plan usually results in a gradual gain in inventory of coal on hand, but the results are not perceptibly inaccurate. A rough check on the consumption as thus determined, and a good check on the economy of combustion, may be obtained by daily weighing the ashes produced. In small plants, or those where, for other reasons, actual weighing of the fuel is impossible, a little practice enables very close results to be obtained by measurement. Separation of the body of fuel in storage into compartments makes the estimation easier. Even split wood, unpiled, can be closely approximated after a few trials.

It is well understood that water meters are not sufficiently accurate for test purposes, and the mechanical difficulties in construction appear to be especially troublesome in the case of hot-water meters. For approximate indications of the daily evaporation of a plant, however, the meter is satisfactory, being in fact the only method practicable of obtaining any statement of the amount evaporated. In all cases where possible, the water should be measured cold. Frequently, where city water is used, the consumer's meter on the suction side of the feed pump may be employed, the suction in such cases being always under pressure. It does not matter if a small amount of this water is used for other purposes than boiler feed, so long as this amount is limited, known, and controlled; the object is to obtain comparative rather than exact figures. The approximate nature of such returns makes periodical readings of the feed temperature and steam pressure, and corrections of evaporation based thereon, unnecessary.

Some curious results are obtained by a careful study of even these rough water-meter readings. In one case, when the plant was partially shut down, the quantity of water consumed appeared to be too large, and it was found upon investigation that the turbine wheel used for removing scale from the tubes of a water-tube boiler, attached to the city water supply, was using $10 worth per day of this commodity at 10 cents per 100 cubic feet. Connection of the water-motor pipe to the condenser pump disposed of this extravagance.

The horse power developed by the engine equipment may be, and in some cases should be, determined by taking indicator cards at frequent intervals. For this purpose, the steam indicator and reducing

motion should at all times be attached to the engine. In an electrically driven mill, the power developed can be, of course, computed without the aid of the indicator. In such a case, it may be desirable, however, to use the indicator as a closer check on engine economy than measurements of electrical power alone would give. Indicator readings of the steam engine in a manufacturing plant do not, however, wholly represent the amount of power developed. Steam is invariably used for other motors than the main engines; sometimes, also, for other than power purposes. It is necessary, therefore, to have some means of arriving at the steam consumption for these various purposes. In order to do this, the engineer must occasionally make economy and duty tests of all engines and pumps, and must devise methods of approximating the quantity of steam used in various processes. Where the steam, after use, can be condensed, it is easy to determine the amount consumed under different conditions. If the steam cannot be separately condensed, the determinations of the amount of flow through a given orifice at various differences of pressure can be made by an independent calibration, in which the steam is condensed, and the figures thus obtained used in computing the consumption in process. This is the method used to regulate and calculate the amount of steam used in fuel-oil burners. The orifice best consists of a small hole drilled through a diaphragm bolted between faced flanges. A set of diaphragms should be provided. By ingenious testing, the engineer may develop rough and ready rules, which are nevertheless surprisingly accurate, for estimating the quantity of steam that is being used by the various pieces of equipment supplied.

This general information is used as follows:—from economy tests of his engines, the steam man will have determined the steam used per horse power between certain limits of load. Multiplying this by the horse power developed, as determined at intervals, he can compute the steam used by the engines. From duty tests of pumps, and observation of the amount and head of liquid pumped (even when approximating these last from the number of strokes), he can estimate the consumption by the various pumps. By weighing the condensation of steam employed to heat a certain weight of liquid through a certain range of temperature, he can ascertain how much steam is condensed per degree of heat for one pound of liquid, and thereafter may calculate the steam used by knowing the quantity and temperatures of liquid. From the calibration test for quantity of steam through an orifice, and by periodical gauge readings, he can obtain an estimate of the steam used or blown into any process from which it is not subse-

quently removed. For purposes where a large and fairly constant amount of steam is required, an estimate of the quantity is sometimes made by supplying this steam from a separate boiler or boilers, and weighing the feed water.

The engineer is then in possession of a statement showing where all the steam generated has been used. This should be balanced against the recorded consumption of feed water. With such data, an increase in cost of fuel can be analyzed with some degree of certainty. It should at least be possible to know whether the increase has been due to improper methods of firing in the boiler-room, or to extravagance in the use of steam. It is also possible to ascertain the cost of steam for improvements and special processes adopted.

This estimation of steam consumption, in addition to being approximate, is also temporary. The steam consumption of engines rapidly increases during a long and steady run. Other factors make the data obtained by tests less reliable as time goes on. It is assumed, however, that without regard to these variations, the engineer will have occasion to make economy trials of most parts of the plant several times in the course of a year; and such economy trials furnish just the data needed for his calculations. These calculations may be made either at the plant, or at the general office, from data furnished by the plant. The former is preferable, but there are few mill engineers who would have time or be ready enough at figures to make the computations. In any case, the final returns, showing proportionate amounts of steam used at various parts of the plant, should be accessible to the engineer.

The fourth item in the general *résumé*, namely, the product of the plant, is of course recorded by the superintendent. It may not in all cases be practicable to place these figures before the plant engineer, but the steam specialist must have them, for the full appreciation of his plant performance. When there are variations in the quality of product, which, like variations in its quantity, affect the consumption of steam, this fact will be indicated from inspection of the details of our third item, "horse power developed," and due regard should be paid such variations in making comparisons.

From the four items listed, the engineer may compute,

Evaporation of water per pound of coal
Power developed per pound of steam
Amount of product per unit of power,

and, by comparison of these figures along horizontal and vertical lines, may determine whether there is a lessened efficiency and a need of adjustment in boilers, engines, or process.

STORES ARRANGEMENT AS A FACTOR IN SHOP MANAGEMENT.

By John Ashford.

A recent request for data as to stores-room practice, sent to a large number of the foremost shops, brought in nearly 75 per cent. of the cases the general reply: "We are not at all satisfied with our methods. Our stores room is in the poorest condition of all the departments of our works. We are thinking of reorganizing it completely." No furtner suggestion is needed to emphasize the importance of Mr. Ashford's exposition of the stores room as the central department of provision, inspection, control, distribution, and protection of the whole works.

The first section, now presented, lays the general groundwork of the subject. A following article goes into specific detail, and will give the definite, practical instructions, forms, cards, etc., of a simple, non-cumbersome, and inexpensive system which will accomplish all the results suggested above, and many others of almost equal importance. It will also illustrate the practice of many of the newest establishments of the United States and Great Britain.—THE EDITORS.

IT IS of but little use to put modern rapid-production machines and tools into a works unless the general scheme of works management and procedure is based upon equally modern lines. It would be about as wise to put modern rapid-fire artillery in wooden ships and expect them to win battles against modern ironclads, as to put high-class machine tools into a works without tool room, stores, and the corresponding methods of management, expecting them to make profits in competition with thoroughly up-to-date establishments. Yet this is actually done—only, however, in those factories where there is a pathetic clinging to the methods and doings of the past—where the way things were done twenty years ago is held up by way of example for the guidance of the rising generation.

The mere saying that there must be modern methods of management is not very helpful and naturally draws the query:—"What *are* the modern methods referred to?" Putting the matter in the most contrasting way we could say that modern methods to old-fashioned ways are as brains to brute force, as the magazine rifle is to the bow and arrow. There were certainly William Tells and Robin Hoods who could perform great feats with the ancient weapons, but every sane drover would pin his faith on the accurately sighted rifle when defending his flock against a pack of hungry wolves. In any factory there are plenty of wolves ready enough to eat up the profits.

quently removed. For purposes where a large and fairly constant amount of steam is required, an estimate of the quantity is sometimes made by supplying this steam from a separate boiler or boilers, and weighing the feed water.

The engineer is then in possession of a statement showing where all the steam generated has been used. This should be balanced against the recorded consumption of feed water. With such data, an increase in cost of fuel can be analyzed with some degree of certainty. It should at least be possible to know whether the increase has been due to improper methods of firing in the boiler-room, or to extravagance in the use of steam. It is also possible to ascertain the cost of steam for improvements and special processes adopted.

This estimation of steam consumption, in addition to being approximate, is also temporary. The steam consumption of engines rapidly increases during a long and steady run. Other factors make the data obtained by tests less reliable as time goes on. It is assumed, however, that without regard to these variations, the engineer will have occasion to make economy trials of most parts of the plant several times in the course of a year; and such economy trials furnish just the data needed for his calculations. These calculations may be made either at the plant, or at the general office, from data furnished by the plant. The former is preferable, but there are few mill engineers who would have time or be ready enough at figures to make the computations. In any case, the final returns, showing proportionate amounts of steam used at various parts of the plant, should be accessible to the engineer.

The fourth item in the general *résumé*, namely, the product of the plant, is of course recorded by the superintendent. It may not in all cases be practicable to place these figures before the plant engineer, but the steam specialist must have them, for the full appreciation of his plant performance. When there are variations in the quality of product, which, like variations in its quantity, affect the consumption of steam, this fact will be indicated from inspection of the details of our third item, "horse power developed," and due regard should be paid such variations in making comparisons.

From the four items listed, the engineer may compute,

Evaporation of water per pound of coal

Power developed per pound of steam

Amount of product per unit of power,

and, by comparison of these figures along horizontal and vertical lines, may determine whether there is a lessened efficiency and a need of adjustment in boilers, engines, or process.

STORES ARRANGEMENT AS A FACTOR IN SHOP MANAGEMENT.

By John Ashford.

A recent request for data as to stores-room practice, sent to a large number of the foremost shops, brought in nearly 75 per cent. of the cases the general reply: "We are not at all satisfied with our methods. Our stores room is in the poorest condition of all the departments of our works. We are thinking of reorganizing it completely." No further suggestion is needed to emphasize the importance of Mr. Ashford's exposition of the stores room as the central department of provision, inspection, control, distribution, and protection of the whole works.

The first section, now presented, lays the general groundwork of the subject. A following article goes into specific detail, and will give the definite, practical instructions, forms, cards, etc., of a simple, non-cumbersome, and inexpensive system which will accomplish all the results suggested above, and many others of almost equal importance. It will also illustrate the practice of many of the newest establishments of the United States and Great Britain.—THE EDITORS.

IT IS of but little use to put modern rapid-production machines and tools into a works unless the general scheme of works management and procedure is based upon equally modern lines. It would be about as wise to put modern rapid-fire artillery in wooden ships and expect them to win battles against modern ironclads, as to put high-class machine tools into a works without tool room, stores, and the corresponding methods of management, expecting them to make profits in competition with thoroughly up-to-date establishments. Yet this is actually done—only, however, in those factories where there is a pathetic clinging to the methods and doings of the past—where the way things were done twenty years ago is held up by way of example for the guidance of the rising generation.

The mere saying that there must be modern methods of management is not very helpful and naturally draws the query:—"What *are* the modern methods referred to?" Putting the matter in the most contrasting way we could say that modern methods to old-fashioned ways are as brains to brute force, as the magazine rifle is to the bow and arrow. There were certainly William Tells and Robin Hoods who could perform great feats with the ancient weapons, but every sane drover would pin his faith on the accurately sighted rifle when defending his flock against a pack of hungry wolves. In any factory there are plenty of wolves ready enough to eat up the profits.

Perhaps I may be excused if I use another analogy. In the present day a general in command of an army employs vastly different methods from those found effective in the days of the Crusades. He employs field telegraphs and telephones, observation balloons, railways, and many other modern inventions to control his various units, to keep touch with his enemy, and to bring forward his supplies; whereas it was no uncommon thing in the days of yore for the prince in command to plunge into the thick of the fight, and to help to win the victory with his own right arm.

In the factory, time was when the successful works manager took no thought of cost keeping, but paraded the shop with thumbs in the armholes of his waistcoat and bullied his men. The days of his success were the times when an engine sold for three times the price that one of similar size, yet more powerful, does today. It is considerably less than ten years ago that some of the largest engine-building factories in Great Britain first started cost keeping. Prior to that they could get practically their own prices, and as the banking account steadily swelled they knew they were all right and troubled not about detailed costs; it was not until banking matters began to change their appearance that such details as cost keeping received consideration. Times have changed and such selling prices will never again prevail; thus reduction in profits imperatively calls for reduced prime costs, and here it is that modern methods come in.

The keynotes of this management are *accurate information* and *system*. The old adage "Knowledge is power" is particularly applicable to a works manager, for, unless he has accurate knowledge of how everything is going, how can he put right that which is going wrong? The word "system" is apt to get hackneyed, and may perhaps convey a wrong impression to some minds unless we explain that to create a system is to provide a pre-arranged way for things to be done. A good system is, in comparison to a happy-go-lucky lack-of-system way of working, as a railway is to the prairie or veldt for travelling, and the smoothness and speed of running are in like comparison. A system, to be of value, must be as simple as is possible to obtain the object in view, and like the railway it should get there by the shortest route and have as few inclines as possible. It must, however, be remembered that a railway line may pay much better if it calls at several important towns en route. For instance, a cost-keeping system is primarily to obtain the total cost of the machine manufactured with a view to fixing a satisfactory selling price, but its value becomes immeasurably greater if en route it gives *detail costs* and also serves to indicate the *progress of work*.

These opening remarks may not at first sight appear to have much bearing upon the title of the paper, so it might perhaps be as well here to explain that in preparing the series of articles* of which this is the last, I had the following leading thought or problem in mind:—Given a factory in connection with which the profits have been a steadily diminishing quantity in spite of a fair share of trade; and upon a full consideration of the matter it is found that the plant is out of date, and it is decided to install modern rapid production machinery—what other steps are necessary to make the new plant a paying investment?

The first half of the solution of the problem lies in the answer that the machines must be properly equipped with tools to tackle their work, and the second half is embodied in the statement that they must be properly supplied with work for the tools to operate upon. Without either tools or work their value vanishes. In treatment of the first part of the problem, I have gone into the matter of draughtsmen to design the tools, tool room to make and prepare the tools, stores in which to keep them, and the means of indicating to the workman at the machine what tools are to be used. It is then the object of this article to make the last part clear, but the subject is more involved than at first sight appears, inasmuch as it strikes directly into important matters of management. Many kinds of high-class machine tools take a considerable time to set up for their work, but when in operation they do it with great speed. Suppose, for instance, a certain job takes two hours upon an old machine, but only ten minutes upon a rapid-production one, and that it takes two hours to set the tools on the latter. Obviously, it would make no reduction in cost to do a number of the articles in succession on the old machines, so they were made a few at a time as wanted; but with the modern machine, a big saving is effected by doing a number at once. If, then, there are many of these machines all requiring to do their work in batches, it makes a great difference in the methods of dealing with the work. The rough material, castings, forgings, or bars, must be supplied to the machines in quantities, altogether in a batch, and when finished, the work must be taken away and stored until wanted, leaving room at the machine for other work to be done. The whole thing seems simple enough, one might say—provide a stores for the rough material and another for the finished work. Not so simple, though, for the following reasons:

A.—Unless work is manufactured in quantities arranged by the management, stocks will be unduly inflated and too much money sunk in them, or bad stock made that may lie long unused.

* THE ENGINEERING MAGAZINE, July and August, 1904.

B.—To ensure that the work shall be wanted in reasonable time, the parts that are stocked must be according to arranged standards.

C.—To ensure that parts when made shall be found correct when taken for use, they must be inspected when manufactured.

D.—As parts will require to be ordered and made in batches, instead of sets for the machines being manufactured, it will probably involve a re-arrangement of the system of ordering and of cost keeping.

E.—As the storing of parts, booking from stores to engines or machines, and cross booking in the cost books, would cause frequent reference to parts, it may be found advantageous to arrange some method of identification by symbols instead of by names.

It is obvious that a fairly strict hold must be kept on stocks by the management, as it is an easy thing in a large engineering establishment to get so much money sunk in stock as to cause financial tightness; on the other hand, if it is cut too fine it will mean manufacturing in small dabs, and frequent delays in executing orders consequent on stocks running out. The actual material and things to be kept in stock should be fixed by the works manager, who would naturally consult his head store keeper, and he should fix maximum and minimum quantities with due regard to the probable requirements of the works and the time it would take to replenish when re-ordering. The fixing of the quantities must be partly controlled also by the effect that quantity has upon economy of manufacture. The minimum quantity is that amount it is desirable to keep as a reserve, and when this minimum is approached or reached, the store keepers must order the quantity that would bring his stock up to the maximum beyond which he is not allowed to go. By fixing these quantities, the manager knows that the money sunk in stock cannot exceed the amount represented by the sum of the value of the maxima, and those who are responsible for the financing will know what they have to reckon with inside the works.

If it will take about three weeks to put through the works an order for the replenishing quantity of a given article, then the minimum quantity must be the average of about five-weeks demands on stores. Unless these quantities are definitely fixed by the management, the working of stores loses much of its value and it may result in a serious state of things. I know of a stores that was run upon very slack, not to say bad, lines. The stores keeper was under the control of the shop foreman, who himself was ignorant of stores operation. There was no attempt to book work either in or out of stores, the labour of booking being considered quite unnecessary and expensive; thus nothing

in stores was accounted for, and work might be drawn by a man for a given machine or engine several times over without anyone being the wiser, or anything being charged against the machine for which it was issued. The making of work for stores was not upon any pre-arranged plan, and the stores keeper was not responsible for the quantities kept. A foreman, if wanting work, would walk into the stores, take a glance around, and then put in hand what quantity he chose of such article as he thought appeared to be running low, the quantity being regardless of the demands for the article. In this way expensive items, perhaps made of brass, would be there in sufficient numbers to last ten years, while others that did not catch the attention would be right out of stock. There is another danger in such casual methods as these; a workman getting hold of a job with a good price to it will run ahead and make an excessive quantity if the foreman is not sharp on him. And still again, there being no check on articles taken in and out of stores, a dishonest man would find it easy to draw articles therefrom to mix with those he was making, and get paid piece work for the lot.

It does not do to stock parts in quantity unless there is a steady demand for them, and to ensure that such shall be the case it is necessary to arrange standard lists of details. The work of standardisation is not easy in a factory where there has previously been but little thought or effort given to such a matter. Where there are no standard lists to work to, the draughtsmen each make the details of the machine they happen to be engaged upon to suit their own ideas or fancy. Thus it comes about that many details of a similar character, such as bolts, pins, bearings, journals, etc., will vary from one another in unimportant dimensions when identical details could be used. This kind of thing precludes effectual manufacturing, and to sort out these various details and scheme therefrom a straightforward progressive list of sizes to be used as standards, demands discriminating judgment. An ideal standard list will be so arranged that the succession of sizes advance by equal progressive steps, all dimensions being proportionate. In practice, however, these lists cannot always be so arranged, a compromise being sometimes necessary to meet various considerations. It is advisable when preparing the standard lists to make them as complete as possible, filling in the various steps of the series, even though not immediately wanted, the stores keeper being advised that these inserted sizes are not yet to be stocked. The object of this is to guide the draughtsmen in their designing, for should they require to include a detail as per standard, the list which gives all dimensions will guide them and prevent an irregular item being introduced.

Standard lists, when conveniently arranged, are extremely useful in all parts of the factory. The draughtsman has them to his hand that he may see what items he can depend upon being in stock; the stores keeper uses them in connection with his stock keeping, for it is convenient to have them marked with those items kept in stores; the piece-work or premium clerk uses them to mark prices or times upon; the workmen use them in making the parts, and the inspectors when viewing and trying work. A convenient size for the lists is about 13½ by 10 inches; they may be mounted on stout millboard and varnished for shop use, or bound in books for the offices.

The method of identifying parts is a matter of importance in all engineering workshops, and the way it is done may have a great effect in either the saving or losing of time. Most establishments are content to name the various machine parts, but this may easily lead to awkward mistakes from the simple fact that the parts are often left on the drawings without names, on account of the draughtsman's faculty for inventing in that direction having run dry. In those establishments how often drawings are marked "6 of this," or "10 of this," any semblance of name being entirely omitted. When that is so, the workmen often coin names for the parts, the name selected frequently having nothing to connect it with the article to be identified. I have found curious instances. Uncertain nomenclature is sure to lead to errors in details manufactured to orders, in cost keeping, and in bookings of various kinds; so a definite system of naming is imperative if accurate information is to be had and errors avoided. For the sake of certainty, lists of all parts in the machines or engines manufactured should be prepared, and against each of these names a number or identifying symbol should be placed. The lists of parts should be to all intents and purposes an idex, arranged with special consideration for ease of reference. These lists of parts can become order forms on which the draughtsman or the internal order department can specify the details required for particular machines. The opposite page shows part of such a list of details prepared by me for engine work.

To explain the method:—The main divisions or parts of the machine or engine are first taken, such main parts for instance as bedplates, cylinders, governors, valve gears, etc., being arranged alphabetically. Under these heads their component parts are next taken also in alphabetic order, and beneath these again the details of the parts are arranged, also in order. The section of the detail list reproduced will be seen to concern a throttle governor. This particular design of governor has certain components—bell-crank lever, casing, levers, sleeve, etc., and these are all in order as sub-components

SPECIFICATION FOR PROGRESSIVE ORDER No. ....

Identification Number.	Drawing No.	Quantity.	Description.	Order Ticket No.	Remarks.	£	s.	d.
16/2			**Throttle governor**					
16/4			" " **Bell crank lever**.....					
16/6			" " " " bracket					
16/8			" " " " fulcrum pin..					
16/10			" " " " washers					
16/12								
16/14								
16/16								
16/18			" " **Casing**					
16/20			" " " door					
16/22			" " " " (special)					
16/24			" " " " sight door hinges					
16/26			" " " " sight door hinges pins..					
16/28			" " " tongue piece					
16/30			" " Centre pads. Standard list No.					
16/32			" " Centre pads. Standard list No.					
16/34								
16/36								
16/38			" " **Inertia lever**					
16/40			" " " " fulcrum pin.					
16/42			" " " " fulcrum pin washers ..					
16/44								
16/46			" " " " link ends ...					
16/48			" " " " link pin					
16/50			" " " " weights					
16/52			" " " " " bolts.					
16/54								
16/56								
16/58			" " **Levers**					
16/60			" " Lever fulcrum pins.....					
16/62			" " " weights					
16/64			" " " " bolts					
16/66			" " **Plate**					
16/68			" " " stop screws					
16/70			.. " **Sleeve**					
16/72			" " " blocks					
16/74			" " " " pins					
16/76			" " " junk ring					
16/78			" " " ring (with or without trunnions) ..					
16/80								

SPECIFICATION OR SCHEDULE OF PARTS, USED AS AN ORDER SHEET, DRAWING LIST, AND COST SHEET.

The gaps in the numbering are left for extensions or insertions. When the form has completed its work as an order sheet, a duplicate is sent to the cost office and the original to the stores, to assist in the accumulation of all details for the erectors or assemblers.

of the throttle governor. Each of these components has its details particularised immediately beneath it, so that any part is quickly found on the list. Thus to find a detail by name on the list—say the junk ring on the sleeve of a throttle governor, the main part of the engine—the throttle valve—is first turned to. In alphabetic position under this main part, the part of the governor—the sleeve—of which the detail is an item, is next found in heavy type, and immediately below that the junk ring, the detail in question, is found. Against each item of the list is an identification symbol in the form of a fractional number. The numerator of this fraction indicates the main part of the engine, say the throttle governor, and the denominator the particular detail of the governor. In the first preparation of such a list, only even numbers are used, all odd numbers being left for future use when adding items to the list. To complete the identification symbol, the type of machine or engine can be indicated by a capital letter such as M for a single-cylinder vertical open-type engine, and the size of the engine by a number; thus the symbol 6M 16/0 would be the complete throttle governor for No. 6 size single-cylinder vertical open-type engine, or again 6M 16/74 would mean the sleeve blocks for the same engine.

This method of identification can expand to an unlimited extent, and is a simple yet effective means of identifying all details, either on paper or in the concrete. Its further uses will become apparent later.

When the senior draughtsman responsible for the preparation of the drawing list is about to prepare such list for the works, he takes the printed identification list of the type of machine and fills the drawing numbers to each item in the column for that purpose, and he also marks the identification number on the drawing itself against the detail so that it cannot be misunderstood if several items are on the same sheet. The completed specification list with drawing numbers on is then handed to the individual or department handling the internal ordering, and a duplicate is prepared. This duplicate is for cost-keeping purposes, and has cash columns for the insertion of the total cost of each item. Before it is handed to the cost clerk, however, it is taken by the stores keeper, who marks against the items in stock the order numbers to which the said items were made. The list then returns to the order department, and the items not in stores are next ordered on the system in use in the establishment, the duplicate specification list with order numbers inserted going to the cost department to show them what is ordered, while the original list goes to the stores keeper to be retained by him until all parts are ready for the erector.

(To be continued.)

EDITORIAL COMMENT

THE return of the members of the Panama canal commission from the Isthmus, after a sojourn of two months, brings every assurance that the work is progressing as satisfactorily as could be expected, in view of the somewhat chaotic condition of affairs incident upon the unsettled condition of things during a number of years.

The work which was being maintained by the French company has been taken over by the commission, and is being carried forward more rapidly, although with a smaller force, than previously, and plans for the rapid extension and systematization of work along the whole line are being matured.

So far as the question of the employment of modern and special machinery is concerned, it is almost too soon to enable any very definite information to be obtained. A portion of the more recent equipment purchased from the French company will doubtless be found of use, but there is an immense accumulation of obsolete and useless machinery and material which is to be collected and sold for junk, thus getting it out of the way and making room for modern appliances.

The labor question has not yet reached a stage where it is open for public discussion, but it is well-known that numerous applications have been made for the supply of labor of various kinds and from various parts of the world. There is every reason to believe, however, that the quantity and character of labor required will differ materially from that which has hitherto been used, and that the introduction of improved and special methods of work will alter the nature of the problem to a great extent. It is more than probable that the question of the kind of labor to be employed will be modified as the work is conducted, and that experience with the problems as they are encountered will result in the designing of special appliances to enable power machinery to be used to the maximum degree. The opportunities for the provision of an ample supply of power along the entire route will aid materially executing such plans.

* * *

IT will be seen that such considerations effectually preclude the immediate announcement of any startling developments in connection with the great work at the Isthmus, and those who expect that the digging of the canal will be "begun" with a great flourish of trumpets and much speechifying will realize that something altogether different is already taking place. There is a very dirty house to be cleaned up, and a lot of useless junk to be disposed of; while at the same time the special appliances necessary for the proper conduct of the excavation and construction have to be both designed and constructed. That the canal is even now really being built is well understood by those who realize the extent to which sanitary and preliminary work forms a part of construction, while the general public may well be assured that this forms as essential a portion of the great undertaking as the digging of the cellar does in the building of a house.

WE have already referred to the manner in which the American Society for Testing Materials appears to have neglected the principal object for which the parent International Society for Testing Materials was formed, and this is a matter to which the attention of the engineering profession may well be directed. The original idea of forming such a society was that of unifying the methods of testing materials and of recording such tests to an extent which would enable the valuable work being done in all parts of the world to be strictly comparable. In addition to the accomplishment of this most desirable object, the International Society has taken up the questions connected with the conduct of such tests, studying the methods which give the most reliable results, and standardizing the practice of its members all over the world. In this most important undertaking the work of the Continental engineers has been extremely valuable, and it is most unfortunate that the American members have seen fit to neglect such associated international efforts. Since its formation the American society has practically become an organization for the discussion of materials of construction in a most general manner—a work entirely within the scope of the existing national societies with which most of the members are already affiliated, and for the conduct of which no new organization was needed.

* * *

MEANWHILE the subject of the unification of methods of testing, for the furtherance of which the Society was originally formed, has been almost entirely neglected, and any attempt to harmonize American practice with that of other countries has apparently been dropped. Various reasons have been advanced for this curious conduct, but it is unnecessary to discuss them in this place. The result cannot but be injurious to the scientific development of American engineering, and ultimately to American commerce in engineering products in other parts of the world, and it should be the duty of all American engineers who have the real welfare of the profession at heart to bend their efforts to the correction of what, to put it in the mildest possible manner, has shown itself to be a distinct blunder.

* * *

THE review of the St. Louis Fair with which Mr. Bryan leads this number, though necessarily brief in comparison with the field to be covered, gives a peculiarly clear and definite idea of the Exposition as an entity. This quality of singleness of conception will appear strikingly when his description is compared with other accounts approaching the subject from the viewpoint of the picturesque, the magnificent, or the sensational. The reason—or one reason—is that Mr. Bryan's study advances by the same steps as the project itself. He reveals its structural lines, and so gives the key to the whole composition and establishes plainly the relations of all its parts. In short, he shows that the entire Exposition, from its first conception to its final detail, is a vast engineering problem, and that it demands and holds the attention not only by what it houses and displays, but by what it is itself. And the truthfulness of the representation is assured to the reader by the discriminating professional judgment and frank, even-handed justice with which Mr. Bryan distinguishes between the perfect and the imperfection in the work as a whole.

It is a real pleasure to be able to add that from the financial point of view—necessarily one of anxious interest to very many of those most interested in the Exposition—the enterprise is in better condition than indications some time ago permitted its friends to hope.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

THE NEW THEORY OF MATTER.

PRESIDENTIAL ADDRESS AT THE CAMBRIDGE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Right Hon. A. J. Balfour.

ALTHOUGH presidential addresses delivered before conventions of scientific societies are not always the most inspiriting reading they demand attention because of the eminence of the men by whom they are written and also because of the high character of the audiences to whom they are delivered. The British Association, as the name of the society is generally abbreviated, has had many eminent presidents, and among the thought inspiring addresses which have been delivered before it many will recall the famous Belfast address of Professor Tyndall, or more recently the review of the food problem of the world by Professor Crookes. At the present meeting the address was delivered by the Prime Minister, the Right Hon. A. J. Balfour, who called his remarks "reflections suggested by the new theory of matter," and naturally such a subject belongs rather to the domain of the physicist than the engineer, but the fundamental problems of engineering are based upon the researches of the physicist, and the two branches of science differ in degree rather than in kind.

After reviewing the general conceptions of the universe from the time of Newton down through the periods in which Young, Stokes, Maxwell, and their followers worked, Mr. Balfour takes up the modern theory of matter, the theory of electrons.

"Electricity was no more to the natural philosophers in the year 1700 than the hidden cause of an insignificant phenomenon. It was known, and had long been known, that such things as amber and glass could be made to attract light objects brought into their neighbourhood, yet it was about fifty years before the effects of electricity were perceived in the thunderstorms. It was about 100 years before it was detected in the form of current; it was about 120 years before it was connected with magnetism; about 170 years before it was connected with light and ethereal radiation.

"But to-day there are those who regard gross matter, the matter of everyday experience, as the mere appearance of which electricity is the physical basis; who think that the elementary atom of the chemist, itself far beyond the limits of direct perception, is but a connected system of monads or sub-atoms which are not electrified matter, but are electricity itself; that these systems differ in the number of monads which they contain, in their arrangement, and in their motion relative to each other and to the ether; that on these differences, and on these differences alone, depend the various qualities of what hitherto have been regarded as indivisible and elementary atoms; and that while in most cases these atomic systems may maintain their equilibrium for periods which, compared with such astronomical processes as the cooling of a sun, may seem almost eternal, they are not less obedient to the law of change than the everlasting heavens themselves.

"But if gross matter be a grouping of atoms, and if atoms be systems of electrical monads, what are these electrical monads? It may be, as Professor Larmor has suggested, they are but a modification of the

universal ether, a modification roughly comparable to a knot in a medium which is inextensible, incomprehensible, and continuous. But whether this final unification be accepted or not, it is certain that these monads cannot be considered apart from the ether. It is on their interaction with the ether that their qualities depend; and without the ether an electric theory of matter is impossible.

"Surely we have here a very extraordinary revolution. Two centuries ago electricity seemed but a scientific toy. It is now thought by many to constitute the reality of which matter is but the sensible expression. It is but a century ago that the title of an ether to a place among the constituents of a universe was authentically established. It seems possible now that it may be the stuff out of which that universe is wholly built. Nor are the collateral inferences associated with this view of the physical world less surprising. It used, for example, to be thought that mass was an original property of matter, neither capable of explanation nor requiring it; in its nature essentially unchangeable, suffering neither augmentation nor diminution under the stress of any forces to which it could be subjected; unalterably attached to, or identified with, each material fragment, howsoever much that fragment might vary in its appearance, its bulk, its chemical, or its physical condition.

"But if the new theories be accepted these views must be revised. Mass is not only explicable, it is actually explained. So far from being an attribute of matter considered in itself, it is due, as I have said, to the relation between the electrical monads of which matter is composed and the ether in which they are bathed. So far from being unchangeable, it changes when moving at very high speeds, with every change in its velocity."

The internal forces which the new theory assumes to be in action within the atoms of matter form a far greater amount of energy than any which appears without these existing in undiminished activity when no external energy is apparent.

"In common, therefore, with all other living things, we seem to be practically concerned chiefly with the feeder forces of Nature, and with energy in its least powerful manifestations. Chemical affinity and cohesion are on this theory no more than the slight residual effects of the internal electrical forces which keep the atom in being. Gravitation, though it be the shaping force which concentrates nebulæ into organised systems of suns and satellites, is trifling compared with the attractions and repulsions with which we are familiar between electrically charged bodies; while these, again, sink into insignificance beside the attractions and repulsions between the electric monads themselves. The irregular molecular movements which constitute heat, on which the very possibility of organic life seems absolutely to hang, and in whose transformations applied science is at present so largely concerned, cannot rival the kinetic energy stored within the molecules themselves. This prodigious mechanism seems outside the range of our immediate interests. We live, so to speak, merely on its fringe. It has for us no promise of utilitarian value. It will not drive our mills; we cannot harness it to our trains. Yet not less on that account does it stir the intellectual imagination. The starry heavens have from time immemorial moved the worship or the wonder of mankind. But if the dust beneath our feet be indeed compounded of innumerable systems, whose elements are ever in the most rapid motion, yet retain through uncounted ages their equilibrium unshaken, we can hardly deny that the marvels we directly see are not more worthy of admiration than those which recent discoveries have enabled us dimly to surmise."

Notwithstanding the clearness with which Mr. Balfour presents the essentials of the electron theory it is evident that he regards it merely as one step further along the scientific highway of successive hypotheses, forming a passing element of an unending journey.

"The electric theory which we have been considering carries us into a new region altogether. It does not confine itself to accounting for the secondary qualities by the primary, or the behaviour of matter in bulk by the behavious of matter in atoms; it analyses matter, whether molar or molecular, into something which is not matter at all. The atom is now no more than the relatively vast theatre of operations in which minute monads perform their orderly evolu-

tions; while the monads themselves are not regarded as units of matter, but as units of electricity; so that matter is not merely explained, but is explained away.

Now the point to which I desire to call attention is not to be sought in the great divergence between matter as thus conceived by the physicist and matter as the ordinary man supposes himself to know it, between matter as it is perceived and matter as it really is, but to the fact that the first of these two quite inconsistent views is wholly based on the second.

This is surely something of a paradox. We claim to found all our scientific opinions on experience; and the experience on which we found our theories of the physical universe is our sense-perception of that universe. That is experience; and in this region of belief there is no other. Yet the conclusions which thus profess to be entirely founded upon experience are to all appearance fundamentally opposed to it; our knowledge of reality is based upon illusion, and the very conceptions we use in describing to others, or in thinking of it ourselves, are abstracted from anthropomorphic fancies, which science forbids us to believe and Nature compels us to employ."

PRESENT PROBLEMS IN TECHNOLOGY.

ADDRESS BEFORE THE CIVIL ENGINEERING SECTION OF THE INTERNATIONAL CONGRESS OF ARTS AND SCIENCE AT ST. LOUIS.

Prof. Lewis M. Haupt.

DURING the past month there has been held in connection with the exposition at St. Louis the International Congress of Arts and Science, this great gathering representing the entire field of modern learning; the leading representatives of theoretical and applied sciences setting forth the general principles and fundamental conceptions connecting the various groups of sciences, reviewing the historical development of special sciences, showing their mutual relations and discussing their present problems.

Among the numerous papers of interest in connection with this important convention, we note that presented before the civil engineering section by Professor Lewis M. Haupt, treating of the present problems in technology, some abstract of which is here given. The scope of the subject is so vast that little more than a general view could possibly be given in the space allotted to a single address, but some of the salient points may be noticed.

In studying the relations of various elements in any department of science it is most desirable that sufficient data should be obtained from the past to enable a curve of progress to be plotted, and Professor Haupt endeavors to select and weigh the data to be used for this purpose in such a manner that the curve may safely be projected for a reasonable distance into the future.

The greatest difficulty encountered in this task is undoubtedly that due to the limitations of the human mind, and it is in its impotence and ignorance that the principal obstacles to the fuller knowledge of the laws of Nature are found. Only by thorough, unbiased research can the laws and facts of the physical world be interpreted and applied. Professor Haupt formulates a general law of development of the successive stages which mark the progress of great enterprises, with especial reference to the antagonistic forces which must be overcome before success can be achieved, showing that these resistances are psychological rather than physical, involving the operation of mind over matter.

The elements which enter into the solution of an engineering problem are more numerous than is generally supposed, including not only the technical training and the subsequent skill derived from experience, but also involving questions of finance, legislation, government, sociology, etc., so that the engineer must necessarily be familiar with the methods of the strategist in the arts of peace.

Taking up the question of transport as one of the great problems of the present day, it is shown that of the three media to be attacked, two, earth and water, have in large

measure been placed under control. Prior to the early part of the last century all the efforts which had been expended upon the building of roads and the maintenance of communication failed to produce any great impress upon commerce and trade. With the introduction of railways, however, the span of a single life has witnessed a complete transformation, not only in methods of communication but in all the arts dependent upon the construction and maintenance of railroads. One of the pressing problems of the present, therefore, is that of the maintenance of an adequate supply of construction material to meet the demand at the increasing rate of requirement. Thus the single item of timber for cross ties leads to questions of irrigation and reforestation, since the demand for structural steel for other purposes renders it impracticable to use it for permanent way construction. Again the lack of timber for bridges and buildings has led to a great increase in the use of steel, while this demand again is being passed on to be supplied by the later method of reinforced-concrete construction, stone and masonry, in a modified form again asserting its old pre-eminence. In all these lines of work there are many pressing problems demanding solution and awaiting the efforts of the engineer. These questions of materials of construction, however, belong largely in the domain of the chemist and the physicist, whose relations to the work of the engineer are growing continually closer and more active.

Another great group of problems awaiting solution are those included in the generation and distribution of power. Originally derived mainly from the energy of falling water, the production of mechanical power received a great impetus with the invention of machinery for obtaining power from heat. This again drew upon the world's stock of stored energy in the form of wood fuel but the limitations of this supply retarded the progress of such machinery, and it was not until the development of the present coal supplies that the great expansion of power generating machinery became a reality. Now the problems under active study and work include the application of liquid and gaseous fuels, and the reduction of wastes and the utilization of by products.

In the mean time the progress which has been made in the electrical transmission of power, has brought once more into the field the great sources of natural water power, and these demand for their economical utilization numerous problems unknown in the older days of smaller units, lower heads, and slower speeds. It is possible that the energy of the waves and tides may yet be advantageously employed, but these are among the questions not yet commercially solved, although many attempts have been made.

Professor Haupt calls attention to the problems yet awaiting solution in the important domain of merchandise transport, in view of the enormous and constantly increasing tonnage.

"Here the problem has been, and still is to increase the ratio of live to dead load and to reduce the resistances by betterments in alignment, grade, distance, and terminal facilities, even at a large increase of capital. Still the delays in handling and drilling trains, composed of relatively small units and containing miscellaneous freights, in complicated yards, and the use of cars for many days for storage, necessitates great expense for which no adequate solution has been provided, although some relief may be obtained by the earliest possible transfer to waterways at the nearest practicable point, thus substituting the short for the long haul in some cases. In others, where bulky freight like ore, coal, or grain is handled, great improvements have been introduced, so that the entire contents of each car may be dumped through chutes into the hold of a vessel at one operation. The capacity of the car has also been increased, so that instead of the paying load being less than the weight of the carrier it is now about three times greater. Probably the greatest advance in economic transportation ever effected was that which revolutionized the movement of petroleum from the oil wells of Pennsylvania to tide water."

What the pipe lines have been to oil must some day be provided for other merchandise and for passengers, and the substitution of continuous for intermittent methods of transport is one of the present problems awaiting solution by the engineer.

The extension of navigation facilities forms another phase of the transport prob-

lem demanding attention. The limit of size, and hence of economy in vessels for water transport has been reached, not for constructive reasons but because of the limitations of harbor entrances. The greatest ports to-day provide insufficient depths for the largest modern vessels, and these are compelled to observe closely the periods of high water and run risks of grounding. Attemps to deepen channels by dredging material while leaving in action the forces which originally deposited that material, are but temporary expedients, and the engineer of the immediate future must accept the truth of the principle which utilizes the natural forces to scour out the channel and maintain its depth permanently.

Professor Haupt touches briefly upon the problems involved in the question of aerial transport, commending the efforts of the managers of the exposition to encourage experiments in this direction.

The magnitude of the problems at present confronting the engineer is indicated by the rate at which the population of the United States is increasing. By plotting a curve from data of recent and past records, it appears that by the year 1950 the country will have a population of 200,000,000, an increase of 260 per cent. and this within the lifetime of many of our contemporaries. With such an increase must come many new questions, but even without these the mere extension of requirements already known must demand the best efforts of the ablest minds in the engineering profession.

"But to be more specific as to the work before us, it may be said, that there is still great need for further improvement in the utilization and transmission of power of all kinds, both by movable and stationary engines;—in the application of natural forces to remove and prevent the formation of alluvial bars in commercial channels;—in the improvement and extension of better highways for the transportation of materials;—in the betterment and standardization of the rolling stock used in the conveyance of freight and passengers;—in the more general introduction of pneumatic plants for the distribution of the mails and for local deliveries in great cities, to reduce the congestion from the delivery wagons;—in the construction of subways for the installation of public-service conduits, sewers, water-supply, lighting, power, drainage, and interurban traffic;—in the original provision, in the planning of cities, for all classes of municipal service, prior to the establishment of new strategic commercial and populous centres;—in the timely equipment of existing towns, in anticipation of the rapid expansion of population, due to the compounding increment of growth;—in additional terminal facilities at points of trans-shipment, to avoid delays and demurrage in port;—in continued efforts to attain practical results in aeronautics;—and in many other special branches of technology, too numerous to mention.

THE MANUFACTURE OF STEEL CASTINGS.

HISTORY, DEVELOPMENT AND PRESENT PRACTICE OF THE ART OF MAKING STRUCTURAL MACHINE ELEMENTS OF STEEL CASTINGS

B. Osann—Stahl und Eisen.

THE growth in the use of steel castings for machine construction has been a notable element in mechanical progress during recent years, and it is a curious fact that in spite of the importance of subject but little available information exists as to its practical technology. For this reason the papers of Professor Bernhard Osann, in recent issues of *Stahl und Eisen* form a welcome contribution to the literature of the subject, and demand review at length. The remarkable display of steel castings at the recent Düsseldorf exposition furnish numerous illustrations of what has been done in this department of work, and add materially to the value of the papers.

Attempts to make steel castings followed close upon the development of the open-hearth process, but the difficulties in the way caused progress to be slow at first. About 1872 attempts were made to cast screw propellers in steel, and gradually sufficient experience with the practical details was acquired, so that after about ten years the use of steel casting for machine parts began to meet with approval, and at

the present time, and especially since the development of the electrical industries, the material has come into most extended use. Indeed, it is fair to say that without the ability to use steel castings the present development in machine construction would have been impossible. Cast-iron, while useful for many purposes, is of but limited application, because of its low tensile strength, brittleness, variability, and low elasticity, while forgings of iron or steel are debarred from many uses, both because of the prohibitory cost and because of the impracticability of forming it into the arregular shapes possible with a material which can be cast in a mould. Doubtless the development which has been made in the use of steel castings is largely due to the demands which have thus been made for a material which should have the good properties of both materials and the defects of neither.

Among the early difficulties encountered in the use of steel castings, the most troublesome were the frequent occurrence of blow holes, the appearance of hot and cold cracks, and the problems of shrinkage, but as a matter of fact these are really the same questions which should be considered in connection with cast iron, except that their greater frequency and extent with steel has made them more conspicuous.

In making steel castings the influence of the high temperature at which the metal is poured upon the refractory material of the mould must be taken into account. This requires great care to be exercised in the selection of the sand and clay for the mould and corresponding precautions in drying and baking. Such moulds necessarily offer a greater resistance to the shrinkage of the casting, and since the shrinkage of steel is much greater than that of cast iron, frequently more than twice as much, cracks are formed in the hot metal as it solidifies, these being called hot cracks in distinction from cold cracks which appear in the finished casting.

The tendency to form blow holes may also be traced to the great shrinkage of the steel, and hence the best method of prevention is to provide ample facility for the mass of the metal to follow the movement of contraction. This is done by providing a number of risers at the points where the best connection with the body of the mould can be effected, besides furnishing a much more liberal sinker head than would be considered necessary for cast iron. By such means, as well as the use of proper precautions to prevent the exterior from cooling too rapidly, the blow holes may be prevented.

A most important portion of the work in the production of satisfactory steel castings, however, must be done, not in the foundry, but by the designer in the preparation of the form and character of the piece to be cast. In this department of the work the same general considerations hold good as in the foundry. The great extent of the contraction of the metal, sometimes as much as ⅜ of an inch to the foot, or more than 3 per cent. of its length, must always be kept in mind. It is evident that unequal shrinkage will lead to the formation of cold cracks and cause internal strains, while uniform shrinkage, even if great in total amount, will not produce these effects. It is therefore most important to design the work in such a manner as to avoid great variations in the masses of metal, keeping uniformity of section as much as possible.

By distributing the material in the form of thin plates, reinforced by ribs of the same thickness, and adopting cellular construction for the parts where the greatest strength is necessary it is altogether possible to permit the various parts to be kept at nearly the same temperature during the operation of casting and cooling, so that shrinkage strains and cracks may be almost entirely avoided. It is also important that sharp corners and angles are avoided, large fillets and easy curves being employed, since any sharp angle partakes of the nature of a nick and forms a ready point for the origin of a crack. It is not too much to say that a large part of the success which has been attained in the use of steel castings has been the result of the education of draughtsmen and designers at these points, while much of the trouble has been due to the neglect of just such sumple precautions.

In the manufacture of steel castings it is important that care be taken in the character of the metal. Especially is it important that the phosphorus, sulphur, and copper be present only in the smallest quantities, and it is only with the best material that the best work can be expected.

Professor Osann illustrates his papers with illustrations showing a number of important steel castings, these including stern posts and rudder frames for large vessels, bed plates for marine engines, heavy gearing, dynamo frames, armatures, and details, besides numerous portions of machines of all kinds many of these having formed portions of exhibits at Düsseldorf. These include pieces from less than a pound in weight up to 50 tons or more, forming examples of actual work, and not merely produced for exhibition purposes, and fully demonstrating the extent to which steel castings are being applied in practical engineering work.

NAVAL BOILERS.

FINAL REPORT OF THE ADMIRALTY COMMITTEE UPON DESIGNS OF STEAM BOILERS FOR USE IN THE ROYAL NAVY.

Engineering.

WE have reviewed at length in these columns the interim reports of the special committee appointed by the Admiralty for the purpose of considering the best forms of boilers for naval service, and now we have the final report of the same committee, which has been officially given to the public. In a recent issue of *Engineering* there are some interesting comments upon the report, and we take occasion to discuss both the report and the comments together.

It will be remembered that the occasion for the appointment of the committee was the dissatisfaction prevalent with the performance of the Belleville water-tube boilers which had been installed in certain important vessels, this dissatisfaction developing into a discussion of the relative merits of water-tube and cylindrical boilers for naval service. The committee, consisting of a number of eminent engineers of acknowledged fairness and freedom from prejudice, has gone about its work with painstaking thoroughness, making experimental trials with vessels equipped with various kinds of boilers, and studying the conditions with much care.

The results of these investigations resulted in the decision that the Belleville boiler was unsuited for use in the Navy, but it was also decided that the cylindrical boiler was not satisfactory, but that some form of water-tube boiler should be used. It was temporarily determined that four types of water-tube boiler should be selected for further use in combination with cylindrical boilers, these being the Babcock and Wilcox, the Niclausse, the Dürr, and the large-tube form of the Yarrow boiler. The final report modifies this decision to the extent of authorizing but two of the above mentioned boilers, the Babcock and Wilcox and the Yarrow, and further permits these to be employed for the entire equipment of a vessel, without the association with cylindrical boilers. This portion of the report may be given intact.

Having concluded their experimental investigations, the Committee are now satisfied that two of these four types—viz., the Babcock and Wilcox, similar to that tried in the Hermes and the Yarrow large-tube, similar to that tried in Medea—are satisfactory, and are suitable for use in battleships and cruisers without cylindrical boilers. In the Babcock and Wilcox boiler the generating-tubes are nearly horizontal; in the Yarrow boiler they are nearly vertical. Each type has its particular advantages, and only long experience on general service can show which is, on the whole, the better boiler. For the present the Committee unanimously recommend both types as suitable for naval requirements.

In making these recommendations, the Committee recognise that the upkeep of any water-tube boiler is likely to be heavier than that of the cylindrical boiler; but they are of opinion that the two types they now recommend will cost less for upkeep than the other types of large straight-tube boiler which they have had under trial.

The Committee make these recommendations after investigations and trials carried out under their superintendence extending over a period of nearly four years.

The ships in which each type of boiler has been tried by the Committee are:—

Cylindrical:—H.M.S. Minerva and R.M.S. Saxonia.

Belleville:—H.M.S. Diadem and H.M.S. Hyacinth.

Babcock and Wilcox:—H.M.S. Sheldrake, H.M.S. Espiègle, and H.M.S. Hermes.

Niclausse:—H.M.S. Seagull and H.M.S. Fantôme.

Dürr:—H.M.S. Medusa.

Yarrow large-tube:—H.M.S. Medea.

Although the Committee have no knowledge of any type of water-tube boiler which is likely to prove more suitable for His Majesty's ships than the two recommended, there are other types which may be considered worthy of trial later on. If any type of boiler is considered, in future, to be of sufficient merit to justify its trial in the Navy, it is recommended that it be fitted in a new vessel not smaller than a second-class cruiser.

As in their previous reports, the Committee do not offer any remarks upon the most suitable type of boiler for small vessels of high speed. From the nature of the case, some form of "express" boiler, with small tubes closely pitched, is absolutely necessary, in order to obtain such a ratio of output to weight of boiler as is required in torpedo-boats and destroyers. For small cruisers, however, which have to keep the sea and act with the fleet, it is probable that a boiler such as the Yarrow large-tube would, on the whole, give better results than the "express" types which have hitherto been fitted.

Commenting on these and other features of the report, *Engineering* says:

The report states that the Yarrow and the Babcock and Wilcox boiler have each its particular advantages, and that which is the better boiler can only be determined by long experience on general service. Certain details are, however, given, and by means of them engineers may, perhaps, be able to form more definite opinions of their own. In the first place, the Committee recognise that the upkeep of any water-tube boiler is likely to be heavier than that of the cylindrical boiler. That may be the case at the present time; but it is possible that when further experience has been gained, the cost of upkeep may be very materially reduced, both in regard to making the boilers more durable—weak features being discovered and eliminated—and by improved and cheaper methods of effecting repairs. The cylindrical boiler has a very long start in this respect. As matters stand, we think it probable that some of the members of the Committee may have been influenced by their experience with boilers of the mercantile marine, and have used this as a standard of comparison. If we were to compare the cost of upkeep of the present water-tube boiler of the best type with that of the Navy return-tube boilers—which it superseded—we doubt whether the debit balance would be always against the water-tube type. It is true that the desire to save weight had at one time led to cylindrical Navy boilers having their tubes crowded together and reduced in diameter to a dangerous extent, thus increasing the chance of breakdown and adding to the cost of repairs; but it is necessary to consider the whole question, and if we take the comparatively mod -n cylindrical boilers of the Minerva and compare them with those of the Cunard liner Saxonia, we find that, weight for weight, the former generated more than twice as much steam as the latter.

An interesting feature in connection with the investigations of the Committee is that relating to the expansion and contraction of the tubes. It has been felt that possibly the effects of expansion might be injurious in boilers in which the tubes were rigidly fastened at both ends, and for this reason the Niclausse and the Dürr boilers, in which the tubes are secured at but one end, permitting free expansion, were at first included. It was evident, however, that this construction was not so advantageous as at first appeared, since these boilers showed numerous bent tubes in service, and were not so capable of being forced as the other types. It is possible that these facts were due to the inability of the internal tubes or partitions to maintain the water in active circulation, and in any case it is evident that having the tubes free at one end does not insure immunity from bending.

One point which has been made against water-tube boilers in general is the great care required to fire them properly. The report, while admitting this fact, shows it to be of minor importance, since good firing was readily obtained during the trials made by the Committee: On this point *Engineer-*

ing makes the following pertinent remarks:

"Skilled firing, we know, is needed to get the most economical results with water-tube boilers, but that, we consider, is not altogether a defect for warship practice. The need for higher intelligence and adequate training is the distinguishing feature of the modern navy. It is no advantage, but rather a danger, for a considerable part of the *personnel* to consist of crude and uninstructed men. If a stoker cannot fire a water-tube boiler—and there is no special magic about it—he should have no place on board a man-of-war. Our constant effort should be to raise the status in every department, and necessity tends to this end. The report states, however, that 'good results can be obtained from Yarrow boilers with engine-room complements new to the ship.' That may be true of these boilers, but they should never be put to the test, if we translate 'new to the ship' as 'new to that kind of ship.'"

Broadly, the report is a very satisfactory document, in that it establishes the fact that the water-tube type of boiler is the best for naval service and that it is unnecessary to couple it with any cylindrical boilers as reserve or auxiliary. The water-tube boiler has established itself on land, and it will doubtless secure as sure a position afloat. Experience will undoubtedly cause improvements to be made and new types will probably compete for admission into the naval service, but in any case we may accept the fact that the day of the cylindrical boiler as the standard in naval vessels is past.

TECHNOLOGY AND MANUFACTURING.

THE INFLUENCE OF SCIENTIFIC ORGANIZATION AND SYSTEMATIC METHODS OF DESIGN UPON ECONOMY IN THE WORKSHOP.

F. A. Neuhaus—Verein Deutscher Ingenieure.

ONE of the interesting features in the development of modern engineering is found in the closer relations which exist between the methods of the designing engineer and those of the workmen in the shop; leading to concessions on both sides, to the great advantage of the business side of the establishment. Formerly the engineer worked out his plans with little attention to the methods by which they were to be executed, and much time and effort were wasted in the shop in carrying out details which had but little influence upon the commercial value of the finished product. Now, however, all this is changed, and the man who makes the plans for the work which is to be done in the shop is expected to be familiar with the methods of manufacture to such an extent as to permit the execution of his ideas to be accomplished to the greatest advantage.

In a paper presented before the Berlin section of the Verein Deutscher Ingenieure, and published in a recent issue of the *Zeitschrift* of the Society, by Herr F. A. Neuhaus, this phase of engineering work is discussed in a very effective manner. Herr Neuhaus is especially well qualified to speak with authority, being himself the director of one of the most important machine works in Germany, besides having had a wide experience with American methods during an extended residence in the United States.

The scientifically trained engineer naturally endeavors to give his work the proportions which are indicated by the forces under consideration, by the strength of the materials employed, and by the mechanical movements involved, but there is no reason why these may not be included in connection with the most advantageous methods of manufacture.

An important obstacle to the maintenance of a systematic method of machine design, emphasised by Herr Neuhaus, is the continual demand of customers for changes to be made in the products to suit their own ideas. Formerly this difficulty existed to a great extent in the United States, but the best establishments in nearly all lines of work now decline to make any alterations in their standard machines, or else make such high charges for changes as to deter the customer from insisting. As a matter of fact, the needs of the customer have generally been so fully studied by the designer that he may well be considered the best judge in

the case, and in most instances this view of the matter may tactfully be impressed upon the purchaser. In the United States this reform has gone so far that in some cases an establishment produces but a single type of machine, and even but one definite size of tool, but these represent extremes which cannot be generally expected.

To carry out properly the idea of the consideration of shop methods in connection with machine design involves also the wide subject of technical education. The designing engineer who has not had practical experience in the shop cannot be expected to bear in his mind the demands of shop requirements to their widest extent, however fully he may desire to do so. It is only by the combination of theoretical knowledge and practical workshop training that the best results can be expected, and to this end much attention should be given in connection with technical education.

Herr Neuhaus compares the difference between the German and the American drawing room, showing how the latter is equipped with data and information concerning the shop standards and sizes, with accepted proportions of standard parts, screw threads, gauges, etc., the designers and draughtsmen being expected to keep these always in mind in their work. Instead of dimensioning parts to the exact sizes demanded by computation, the nearest shop size is used, the range of sizes, and consequently of tools, gauges, jigs, etc., being correspondingly limited. The question of the dimensions of cylindrical parts is cited as bearing especially upon this matter. These are classified according to operation, into running, standing, and forcing fits, according as the journal is to revolve, remain stationary, or be forced into place by hydraulic or screw pressure. The use of limit gauges is included in this matter, and instead of leaving the allowances to the shop, the draughtsman is provided with the proper information, and required to arrange his work accordingly.

Another point which, when properly considered, makes a material difference in the cost of machining, is found in the selection of the curves for fillets on finished work. Thus the engineer who draws a parabolic curve uniting the body of a connecting rod with the stub end knows perfectly well that this will require much time and care for its reproduction in metal, while if he ascertains the diameters of the available milling cutters with which the work can be done, he can choose such a radius as will permit the tool itself to finish the work accurately to size without difficulty or loss of time.

Again, in the design of a series of products, such, for example, as a line of steam engines, the engineer who takes the shop work into account will so arrange his dimensions that a number of parts will serve for more than one size of machine, waiving strict exactness for an average proportion which will cut down the number of variations in size to about one-half what might otherwise be made.

The question of accessibility to working and adjustable parts is one which is too often neglected by the theoretical engineer who has not been there himself, so to speak. Nuts which are used for making adjustments demand room for the wrench to swing through the proper angle without having the skin knocked off the knuckles of the operator. Engine housings should be made with sufficient openings to permit complete access to the bearings, crank pins, and other working parts, while the provisions for lubrication demand similar experienced forethought. The writer well remembers a design for a saw for cutting off hot metal, the regulating handles of which were so arranged that the operator was obliged to lean over the bar of hot metal in such close proximity as to scorch his clothing; and yet this machine was designed by a man of reputation, who failed to perceive that the circle on paper representing the cross section of the bar of metal meant a mass of metal at a red heat.

Herr Neuhaus comments on the difference in engine details in vertical and horizontal engines when the parts fulfil practically the same functions. Thus in the case of vertical engines there appears a general use of framing composed of turned wrought-iron pillars; also forked connecting rods are in evidence, with one-sided slipper-guide cross heads. Horizontal engines, however, are rarely so made, even when constructed by the same firms, and the idea of using the same connecting rod and cross-head for a vertical and a horizontal engine, would be

regarded as rank heresy, in Germany, at least.

These are but a few of the points made in this most interesting paper, but they will serve to illustrate the importance of combining technical and practical knowledge on the part of the designing engineer if the products of his ingenuity are to be made commercially successful. When competition was less strenuous than at the present time it might have been possible for the plans for shop work to be made in independence of the means by which they were to be executed, but that time is long since past, and the successful engineer of to-day must keep in close touch with the men and the methods to be employed in the execution of his designs. A close observation of the requirements of both machinist and customer, together with a keen appreciation of the advantages of mass production, repetition work, and the fullest use of modern shop facilities, these must be united to brilliant inventive faculties and thorough technical training, if full success is to be attained.

DIRIGIBLE BALLOONS.

METHODS OF BALANCING AND MAINTAINING STABILITY IN MECHANICALLY PROPELLED AND GUIDED BALLOONS AT HIGH SPPEDS.

Col. Ch. Renard—Académie des Sciences.

AMONG the earnest workers in the field of aerial navigation the name of Col. Renard is well known, he having made some of the earliest experiments which showed any degree of success in propelling and guiding balloons; and his dirigible balloon, *La France,* constructed in 1884, demonstrated the ultimate possibility of making such machines successful when motors of sufficient lightness and power should be provided. This machine contained many of the elements which have to-day been found essential, including the cigar shaped gas bag, with the greatest diameter in advance of the middle of its length, the rudder being placed in the rear and the propeller at the front end, but the weight of the electric motor and batteries made high powering impracticable, and hence the balloon was not able to be operated against strong winds. Since that date the great advance which has been made in the construction of light-weight internal-combustion motors has made it possible to give sufficient power to such machines to make them much more effective, and thus modern experimenters are again working on the lines laid down by Col. Renard twenty years ago.

In these columns we have noticed at different times various communications which have been made upon these subjects by this veteran experimenter, and we now have a communication made by him to the French Academy, and published in *Comptes Rendus,* bearing upon the important question of the maintainance of the stability of dirigible balloons, a matter which has shown itself to be a serious one when high speeds are attempted.

The experiments of Santos-Dumont and others have proved what is also indicated by theory, that for balloons of symmetrical form there is a critical speed beyond which violent pitching occurs, and as this critical speed is the relative speed of the balloon as compared with the surrounding air, it may be attained by reason of a head wind, even when the actual velocity of the machine is low.

There is no doubt that many disasters have been due to the lack of stability which thus occurs, and one of the most important questions to be solved in connection with aerial navigation is the matter of balancing and the maintenance of stable equilibrium at all times.

In his present communication Col. Renard maintains that the true principle of construction in this respect is similar to that which appears in the arrow. An arrow flies through the air toward its mark without pitching or oscillations because the heavy head concentrates the greater portion of impelling energy in the part forward of the centre of gravity, while at the same time the feathers guide and hold back the rear portion and act to steady the whole. By using a long gas bag of comparatively small diameter, with the propeller placed

at the front end, pulling, as it were, instead of pushing the machine through the air, the first step toward stability is attained, and to this arrangement, Col. Renard proposes to add the equivalent of the feathers in the arrow, and thus give the apparatus satisfactory stability at any speed which may occur in practice.

The method of "feathering" proposed by Col. Renard consists in the addition, on each side of the gas bag, at the rear portion, of short cylinders of smaller diameter than the main envelope, these cylinders to be made of the same fabric as the gas bag and to be inflated with air. He also proposes to place the *ballonet*, or part of the main balloon which is inflated with air to keep the whole in a taut condition, in the rear part, these modifications providing a retarding effect upon this part of the machine, and causing it to oppose the pull of the propeller at the front in such a manner as to reproduce the steadying effect of the feathers on the arrow.

Various modifications of this ingenious arrangement are given, and groups of smaller guiding cylinders in twos and fours are sketched, and the computations for the proportions to insure satisfactory stability are shown to be simple and conclusive. The whole forms another of the important contributions which have been made by Col. Renard to the subject of practical aeronautics, and we may expect to see it applied in practice by succeeding experimenters.

In this connection it is interesting to note that Col. Renard is himself not such an enthusiastic advocate of the dirigible balloon as he once was, the improvements in light and powerful motors having led him to turn his attention to the possibility of making a successful machine both lifted and propelled by screws. It appears, however, that still greater advances in motor construction must be made before this plan can be considered available, although it is probable that a toy machine could even now be made in this way. When the problems of balancing and propulsion in connection with the development of the aeroplane, are solved, we may look more confidently in that direction for ultimate success.

It must be remembered that even a machine which possesses in itself the elements of success must be operated by those skilled in the difficult balancing which is evidently necessary. The clumsy flapping of the young bird, just pushed over the edge of the nest by its experienced mother, shows us that something more than instinct is necessary, even for the bird, and surely we may expect that as much practice may be required for flight as is needed to learn to ride a bicycle, for example.

It is possible that a combination of the aeroplane with the dirigible balloon might form a machine in which the management of the former could be learned while under the kindly support of the latter, much as the timid beginner learns to swim by the aid of an air belt, the support being gradually withdrawn as the experience is gained. The two machines may yet be combined into one structure, the supporting force of the gas bag relieving only a portion of the total weight, and leaving the balance to be provided by the planes of the aeroplane. It is evident that in any case the machine alone will not be sufficient, but that experience in operation must be added, and some method of gaining this experience appears to be an essential element in final success.

The solution of the problem of aerial navigation, carrying with it, as it does, the control of such important matters as the conduct of warfare and the liberation of international commerce, demands much more serious scientific treatment than has hitherto been given to it. Instead of the sporadic experimental work which has been possible by the efforts of a few unaided individuals, the matter should be considered as one to be attacked by a continual series of experiments, directed by the best scientific ability, under the auspices of the most powerful civilized nations.

In this way, and probably in this way alone, can the repetition of useless and disastrous trials be avoided, while the united efforts of the scientific and industrial world will be brought to bear upon the problem. Such are the methods which have been used in the application of engineering to machinery of warfare and destruction, and there is no good reason why they should not be applied to a matter of at least equal importance to mankind.

THE DEVELOPMENT OF INVENTION.

THE RELATION OF THE DEVELOPMENT AND PROTECTION OF MECHANICAL INVENTIONS TO HUMAN WELFARE.

Hon. C. A. Parsons—British Association for the Advancement of Science.

IN the course of his address before the Engineering Section of the British Association for the Advancement of Science, the President of the section, Hon. C. A. Parsons, brought out some interesting points in connection with the nature of the protection which he believes should be given to aid in the development of engineering inventions.

Referring to the ordinary conception of invention as that of a happy thought occurring to an inventive mind, Mr. Parsons shows the erroneous nature of such an idea, and maintains that what is usually called an invention is the work of many individuals, each one adding something to the work of his predecessors, each one suggesting something to overcome some difficulty, trying many things, testing them when possible, rejecting the failures, retaining the best, and, by a process of gradual selection, arriving at the most perfect method of accomplishing the end in view.

"Then, after the invention, which we will suppose is the successful attempt to unravel some secret of Nature, or some mechanical or other problem, there follows in many cases the perfecting of the invention for general use, the realisation of the advance or its introduction commercially; this after work often involves as great difficulties and requires for its accomplishment as great a measure of skill as the invention itself. of which it may in many cases be considered as forming a part."

In order to explain his views more fully, Mr. Parsons takes the case of the development of an invention of which we have the full history, and reviews the progress of the internal-combustion motor as an example of the growth of the machine from the early conceptions to its present commanding position.

"The first true internal-combustion engine was undoubtedly the cannon, and the use in it of combustible powder for giving energy to the shot is strictly analogous to the use of the explosive mixture of gas or oil and air as at present in use in all internal-combustion engines; thus the first internal-combustion engine depended on the combination of a chemical discovery and a mechanical invention—the invention of gunpowder and the invention of the cannon.

"In 1680 Huygens proposed to use gunpowder for obtaining motive power in an engine. Papin, in 1690, continued Huygens' experiments, but without success. These two inventors, instead of following the method of burning the powder under pressure, as in the cannon, adopted, in ignorance of thermodynamic laws, an erroneous course. They exploded a small quantity of gunpowder in a large vessel with escape-valves, which, after the explosion, caused a partial vacuum to remain in the vessel. This partial vacuum was then used to actuate a piston or engine and perform useful work.

"We come a century later to the first real gas-engine. Street, in 1794, proposed the use of vapour of turpentine in an engine on methods closely analogous to those successfully adopted in the Lenoir gas-engine of eighty years later, or thirty years ago. But Street's engine failed from crude and faulty construction. Brown, in 1823, tried Huygens' vacuum method, using fuel to expand air instead of gunpowder; but he also failed, probably on account of the wastefulness of the method.

"Wright, in 1833, made a really good gas-engine, having many of the essential features of some of the gas-engines of the present day, such as separate gas and water-pumps, and water-jacketed cylinder and piston.

"Barnett, in 1839, further improved on Wright's design, and made the greatest advance of any worker in gas-engines. He added the fundamental improvements of compression of the explosive mixture before combustion, and he devised means of lighting the mixture under pressure, and his engine conformed closely to the present-day practice as regards fundamental details. No doubt Barnett's engine, so perfect in principle, deserved commercial success; but either his mechanical skill or his financial

resources were inadequate to the task, and the character of the patents would seem to favour this conclusion, both as regards Barnett and other workers at this period. Up to 1850 the workers were few, but as time went on they gradually increased in numbers; attention had been attracted to the subject, and men with great powers and resources appear to have taken the problem in hand. Among these numerous workers came Lenoir, in 1860, who, adopting the inferior type of non-compression engine, made it a commercial success by his superior mechanical skill and resources. This stage of the development being reached, the names of Siemens, Beau de Rochas, Otto Simon, Dugald Clerk, Priestman, Daimler, Dowson, Mond, and others, appear as inventors who have worked at and added something to perfect the internal-combustion engine and its fuel, and who have helped to bring it to its present state of perfection.

"In the history of great mechanical inventions there is, perhaps, no better example of the interdependence of the engineer, the physicist, and the chemist than is evinced in the perfecting of the gas-engine. The physicist and the chemist together determine the behaviour of the gaseous fuel, basing their theory on data obtained from the experimental engines constructed by the mechanical engineer, who, guided by their theories, makes his designs and improvements; then, again, from the results of the improvements fresh data are collected, and the theory further advanced, and so on till success is reached. But though I have spoken of the physicist, the chemist, and the engineer as separate persons, it more generally occurs that they are rolled into one, or, at most two, individuals, and that it is indispensable that each worker should have some considerable knowledge of all the sciences involved to be able to act his part successfully.

Reviewing this series of inventions and labors, Mr. Parsons maintains that the length of time required for the development of the engine from the primitive beginnings might have been materially abridged had the Patent Office undertaken for the successive inventors the searches which would have informed them of what had been done before, similar to what is done in the United States and in Germany. The absence of this knowledge also frequently acts as a deterrent to business men, preventing them from embarking in the exploitation of an invention from the fear of the appearance of an anticipation.

The point upon which Mr. Parsons makes the strongest argument, however, is the fact that the present brief duration of a patent is a positive barrier to the development of some very important undertakings which might well otherwise be accomplished.

Thus the successful solution of the problem of aerial navigation demands more time than could be obtained under the existing patent laws.

"This problem could undoubtedly be successfully solved by an organised attack of skilled and properly-trained engineers and the expenditure of a large sum of money. Assuming the problem solved, and commercially successful, it appears to be impossible under the existing patent laws to secure any adequate monopoly so as to justify the expectation of a reasonable return on the capital, expended on the invention. For in view of the multitude of suggestions that have been made and the experiments that have been carried out, the practical solution of the problem would appear to rest on a judicious selection of old ideas by means of exhaustive experiments."

Another illustration, of which much has been said in the newspapers, is the possibility of making a borehole of several miles in depth, for purposes of geological investigation, an undertaking which could well be accomplished if protection in the form of a monopoly for a sufficient length of time could be secured. As it is tersely put:

"At the present time there is no adequate protection, or, indeed, any protection at all for the promoters of many great and important pioneer enterprises, some of which might prove of immense benefit to mankind."

The remedy which Mr. Parsons has to suggest for this state of affairs is that of an extension of the duration of the life of patents, making this variable according to the subject matter of the invention, or possibly according to the amount of money which the promoters might pledge themselves to spend within a certain time for the development of the project. Such a

plan would also involve international co-operation, in order to prevent to throwing open of a patent abroad while it still remained a monopoly at home.

While there is much to be considered in these propositions it is a question whether the world at large would be benefited by any extensive lengthening of the life of patent monopoly for inventions. The experience with the tenure of land has shown that when ample time is given the owner, secure in his title, will often await the work of others to improve the surroundings before he himself will do anything, and in the United States there has recently appeared a disposition to juggle the patent law so as to defer the issue of inventions for many years, until the work of industrious inventors and manufacturers has shown it to be time to release the old invention upon those who have really done the work.

It is the general experience that the expiration of a patent is the signal for a sudden development in that department of industry, if the invention is of any value, and since it is to stimulate just such a development that the original monopoly is granted, any such extension of time would cause the invention to become obsolete before giving it to the public. The greatest business enterprises in the world have grown up without other monopoly grants than those which the commercial ability of the projectors has been able to create, and these will generally be forthcoming when the inducement offered is sufficient.

HYDRAULIC LIFT LOCKS.

THE NEW HYDRAULIC LIFT LOCK ON THE TRENT CANAL AT PETERBOROUGH, ONTARIO.

J. M. Bulkley—Engineering Record.

CANALS have many advantages as routes for the economical transport of merchandize, but they are limited by one positive requirement, the necessity for maintaining a level surface; there can be no grades on a canal. The use of locks to overcome the differences of level between the various portions of a canal is a very ancient method, but it is limited in the range of elevation which can be surmounted by a single lift, so that a number of locks are required when the height is great. Numerous plans have been devised as substitutes for the old-fashioned canal lock, these including inclined planes, up which the boat is hauled; cylindrical tanks, in which the boats can be rolled up-hill, pneumatic lifts, hydraulic lifts, screw lifts, and a variety of modifications of these plans.

The first hydraulic lift for canal use in America has just been completed at Peterborough, in Canada, and from a description by Mr. John McClelland Bulkley in a recent issue of the *Engineering Record* we give some account of a system which has been found to possess many advantages.

"Like many engineering projects of magnitude, the lift lock has been perfected by a process of evolution. The pioneer lock was built at Anderton, England, and connects a local system of canals with the River Weaver, serving principally the carriage of products from salt works in the vicinity. The lift at this dock is about 50 feet, but its barge capacity is relatively small, the chambers being only 70 feet long by 14 feet wide. No receiving pit was provided, the chambers discharging directly into the river. Pumps were also used to assist in taking the load. The construction is of plate girder design. In France the second lock was built, at Les Fontinettes. It is of moderate dimensions, the canals of the district being only 17 feet wide. The third lock is at La Louviere, in Belgium, on the Canal du Centre, and is of the truss girder pattern. These locks have been more or less successful, and while the operation showed conclusively that the principle of a hydraulic lift lock is a correct one, defects were apparent that could be avoided in the construction of other locks.

"The special functions of the Peterborough lock are, first, to overcome the elevation; second, to reduce the time in which this duty is to be performed; third, to furnish ample capacity for a given number of lockages or the maximum quantity of tons to be handled, avoiding a congested

traffic. The question for the Department of Railways and Canals to decide was whether the lift should be overcome by locks of the ordinary type, or by such a form as that under consideration. If of the ordinary type, then at least five locks would be required. When these were in use, boats and barges would have to wait until the five lockages had been effected before gaining access. To avoid such delay the locks would have been built in pairs, as is the case at Lockport, on the Erie Canal. The cost of these ten locks would have far exceeded the outlay for the hydraulic lock. The time of lockage would have been a serious hindrance to traffic, the attendance a very serious item, and the service would have been slower, continually interrupted, and the capacity of the canal at this point restricted. Hydraulic lift locks are planned and built to serve the future as well as the present and to provide for expansion."

The principle of the lift lock is extremely simple, it consisting merely of two tanks placed side by side and supported on plungers working in hydraulic cylinders. The two cylinders are connected by a pipe so that water can flow from one to the other, and when one plunger, with its tank, is at the top of its stroke, the other is at the bottom, the two tanks balancing each other. Since the boat displaces exactly its own weight of water, the balance is maintained when boats are in the tanks just the same as when they are filled with water, the water being at the same level in both. The proper excess of water being run into the upper tank it descends, forcing the other one to ascend, and this action is repeated whenever a boat is to be raised or lowered. At Peterborough the lift is 65 feet, and this elevation is to be surmounted in about 3 minutes, giving a great gain in time, saving of water, and increase in capacity over the old system of successive chamber locks in series.

In the construction of such a system there are many details which render the undertaking a difficult one, in spite of the simplicity of the principle. The great plungers are 90 inches in diameter, built up of sections of cast iron, while the cylinders, of steel, stand a working pressure of 600 pounds per square inch. The tanks are carried on double cantilever trusses, and the whole is erected upon massive masonry foundations, with guide towers and walls. The joints between the tanks and the gates which close the ends are made tight by a packing of rubber sealing tubes, these being inflated by an air pressure of ten pounds per square inch, this effectually preventing the escape of water, a similar packing being used on the gates which close the ends of the canal reaches.

"An ordinary lockage will be conducted in this manner: Suppose 100 tons of 'surcharge' has been found to give sufficient additional weight to the descending chamber. The uppermost chamber will then be required to stop with its floor 8¼ inches lower than the bottom of the upper reach. On communication being established between it and the reach it will receive from the reach 100 tons more than the lower chamber contains, assuming the depth in both reaches to be the same. Then the total operations to form the lockage, assuming that the gates adjoining the reaches are open and that the seal tubes between the chambers and reaches are inflated, will consist in hauling the vessel into the chamber and mooring her there securely, closing the gates, deflating the seal tubes, and opening the main valve between the presses. The heavier chamber will commence to descend, the motion being allowed to increase gradually by the gradual opening of the valve, until it reaches the maximum speed. At about three quarters of the stroke the main valve is slowly closed, communication between the presses being entirely cut off when the end of the journey is reached. The change in elevation being made, the seal tubes are inflated, the gates are opened, and the vessel or vessels are free to go on their journey, after being towed out by the capstans. The surcharge contained in the descending chamber simply flows out into the lower reach, while a similar quantity to perform the next lockage is admitted into the chamber which has just reached the higher elevation.

"The advantages claimed for the hydraulic lock over those of the ordinary type are saving of time, economy of water and increased capacity. With reference to capacity, it will be noticed that vessels traveling in opposite directions may be locked through simultaneously."

SINGLE-PHASE ELECTRIC TRACTION.

PRACTICAL OPERATION OF SINGLE-PHASE ELECTRIC MOTORS ON THE BALLSTON DIVISION OF THE SCHENECTADY RAILWAY.

Electrical World and Engineer.

WE have already referred in these columns to the rapid development which is being made in the application of single-phase motors to electric traction, and this is further emphasised by the success which has been attained by the General Electric Company in connection with the operation of the Ballston Division of the Schenectady Railway. Recently a demonstration of the operation of the car thus equipped was made before a visiting party of engineers, and from an account of the equipment given by the *Electrical World and Engineer* we make some abstract and review.

"The motor is of the commutator type, possesses the true series characteristics, and it operates equally well with direct or alternating current. In mechanical construction the motor differs from the direct-current machine only as regards the field structure, the armature core, winding and commutator, being essentially equivalent to what is considered best design in direct-current traction motor practice, a four-polar wave winding suitable for operation with two brushes. As applied to the motor in question, the brushes are of standard width and size, and the holders are permanently fixed at the neutral position. The width of air-gap adopted is about twice that employed with stationary induction motors of corresponding size. The field core has no projecting poles, but is built up of laminated rings with distributed slots in which are placed windings similar in many respects to those used with two-phase induction motors, one phase winding, however, containing several times as many turns as the other.

"The machine belongs to that class designated as 'compensated series' motors. This term, as ordinarily applied, refers to those motors in which the inductance of either the field or armature winding is neutralized by counter current in an additional winding placed in inductive relation to the corresponding coil. In this class falls the motor whose field inductance is counteracted by a short-circuiting connection through brushes on the commutator in line with the field magnetism, the current induced in the secondary brush circuit when the armature is stationary being in phase opposition to the current in the field coils. This class includes also that type of motor which uses a short-circuited coil placed upon the field core in an inductive position with respect to the armature winding and in which the current produced by transformer action opposes in magnetomotive force the armature current and thus nullifies more or less completely the active inductance of the armature. The type which the General Electric Company uses differs from the latter in that the current in the compensating coil, instead of being produced inductively, is caused to flow therein on account of the fact that the compensating coil is connected in series (opposition) in the main motor circuit. Thus the compensation in this third type may be designated as 'forced' in distinction to that of the other two types, which is 'induced.'"

The armature, field, and compensating circuits of the General Electric motor are connected in series. If the effective turns of the compensating coil be equal to those of the armature, the resultant inductance of the two will be represented by the small leakage effect of the magnetism around the individual turns of each coil and will be practically negligible, so that, if the inductance of the field coil be made small, the total inductance of the motor circuits will be correspondingly small and the power factor at any operative speed will be relatively high. While in the induced type of compensated motor the secondary current can never quite equal the primary in magnetomotive force, in the forced compensation type the compensating coil can be given any value of magnetomotive force relative to the armature and the machine may be over compensated if desired, certain detrimental effects being produced, however, when the compensation is excessive.

"Such a motor is well adapted to opera-

tion by direct current, the commutation being practically perfect on account of the fact that the field distorting effect of the armature magnetomotive force is balanced by the magnetomotive force of the compensating coil when the turns on each are properly related. The compensating circuits of the machine being in all respects equivalent to the balancing coils on the early Ryan type of non-sparking, direct-current is beyond criticism and for alter-commutating tips are not required for holding the field magnetism in the proper mechanical position. The service tests demonstarted that the commutation for direct current is beyond criticism and for alte-nating current it is satisfactory."

An important feature in the line at Schenectady is found in the overhead work, this being arranged to permit the car to be operated over the same tracks as others using the continuous current.

"The direct-current trolley and feeder conductors have not been disturbed. Over 11.6 miles of the 15.5 miles between Schenectady and Ballston additional No. 4-0 wires were strung and fed at one point with 25 cycles alternating current at 2,200 volts. Upon the regular center poles spaced 100 ft. apart were placed 5-ft. cross arms, holding on each end high-potential porcelain insulators, similar to the ones used on transmission circuits. On these insulators were strung two 3/8-in. steel cables, from which were suspended the high-potential trolley wires clipped to the steel cables midway between the poles. While this catenary construction is exceptionally flexible and gives the best of insulation to the high-potential conductors, it is believed that, where only alternating-current wires are used, standard trolley line construction as now employed with direct-current equipments will prove entirely adequate."

The arrangement of placing the line at the side of the car, with a low-running trolley is also applicable to the conversion of steam railways to electric traction, since the wires are not exposed to the action of the discharge gases from locomotives, and the whole comes well within the limits of the railway loading gauge.

Comparative trials with alternating and continuous current on the same line show practically no difference as regards maintenance of speed and ease of control. Average speeds of 32 miles per hour were maintained in both cases, the car starting from rest equally well with either system, and the test of practical service has been impartially applied.

While these results are of great interest and value as regards the introduction of the alternating current into street railway service, they have a still more important bearing upon the far wider problem of the replacement of steam by electricity on main-line railways. It is practically admitted that the continuous-current systems are not well adapted for long-distance railway service, besides which the enormous cost of replacing the motive power plant has operated as a bar to the consideration of the subject by railway officials. If, however, it is made possible for the short-haul business to be operated by electric traction over the main lines, without interfering with the steam haulage of the freight and through trains, the opportunity is afforded for the gradual replacement of the one system by the other, the steam machinery being discarded as it is worn out, without requiring any immediate and wholesale scrapping.

A very important feature of the electric system is the possibility of running the railway cars upon the street-railway tracks of the cities, and delivering the passengers at any desired point, instead of dumping them out at a station to find their way about as best they may. As we have pointed out more than once in these columns, the real running time for the passenger is measured between his own terminals, and it avails him but little for the train to make a high speed when he has to waste much time to make the connections at the terminals. When a man can take a trolley car at his own door and be carried directly through the streets, out on to the main line, and finally into the streets of the city of his destination, much of the rush and hurry and inconvenience of railway travel will be avoided, and the day of the overgrown nuisance known as the union railway station in our great cities will be over. The ponderous train, hauled between one great terminal and another, was the natural outcome of the use of the steam locomotive, but the release from this system appears to be in sight.

THE CONSTITUTION OF PORTLAND CEMENT.

RESULTS OF THE MICROSCOPIC EXAMINATION OF PORTLAND CEMENT CLINKER CONSIDERED AS A SOLID SOLUTION.

Clifford Richardson—Association of Portland Cement Manufacturers.

THE whole study of metallic alloys has been revolutionized by the application of the microscope, and the science of metallography, derived from that of petrography, or the study of rocks, is now firmly established. An extension, or rather a reversion, of this method has now been applied to non-metallic substances, and the result is a new theory of the constitution of Portland cement, considered from a physico-chemical standpoint. This theory has been presented in a very complete manner in a paper presented at the Atlantic City meeting of the Association of Portland Cement Manufacturers, and from a reprint of this paper in the pages of the *Engineering Record*, we make some abstracts.

The use of the microscope in such investigations is based upon the theory that it is not only the chemical composition of a material which determines its properties, but that the physical arrangements of the constituents also has an important influence upon its behaviour. In the case of metallic alloys it has been found that the physical constitution can be studied by polishing the surface and then etching it with acid or other suitable material, the arrangement of the structure then becoming readily apparent under a proper degree of magnification. In the case of rocks, cement clinker, and similar materials, it is found better to prepare transparent sections by grinding the piece down until the transmission of light becomes possible, the structure then becoming plainly visible under the microscope. In such studies the use of polarized light is of great value, the methods being practically the same for cement as have already been employed with success in the examination of rock sections.

"Among the theories advanced as to the constitution of Portland cement there are those which assume the presence of certain so-called silico-aluminates, such as $2SoO_2$ Al_2O_3 6CaO and others of less basic form. All of these proposed compounds have been prepared by the writer and found not to be definite chemical compounds, nor to correspond in any way with any of the mineral entities found in industrial clinker. They are in fact only solid solutions, of aluminates in silicates, of indefinite structure.

"This brings us to the point where the nature of a solution, especially of solid solutions, must be taken up.

"Solutions may be defined as the merging of two or more substances in one another in such a way that it is impossible to recognize them by any physical means. In this respect they differ from the elements and definite chemical compounds. The elements cannot be or have not been differentiated by any chemical or physical means into other substances. Definite chemical compounds can be differentiated by chemical means into their constituent elements, but at the same time are always composed of these elements in a definite mathematical ratio, involving only whole numbers and depending upon the combining weight of each element.

"Mixtures of gases, gases dissolved in liquids, liquids which are mixed together and salts dissolved in liquids are types of solutions. In the preceding paragraph mention has been made of solid solutions. We owe our conception of such solutions to Van't Hoff, a Dutch chemist, who, in 1890, having observed some abnormal features in the behavior of certain solutions of solids in liquids when they were frozen, was led to believe that the solid which separates on freezing is not the pure solvent, but a mixture of the solid solvent and the dissolved substance forming a solid solution. Investigations have proved that the conception was justified. Roozeboom has shown from a study of mixtures of fused salts that on cooling solid solutions are often formed, especially if the salts have the same crystalline form and habit.

"The constitution of our igneous rocks may best be explained by considering them as solid solutions, which, when the original liquid magma, from which they are derived,

is cooled to a temperature at which freezing sets in, are formed by the crystallization of such mineral species as the constution of the magma may permit, and which we recognize as quartz, mica, felspar, etc., the composition of which, while in approximately definite proportions, is more or less modified by the substances which they may retain in solution."

The old theory of Portland cement considered it as a true chemical compound, a silico-aluminate, but Mr. Richardson decided to investigate the subject upon the theory that, in a parallel manner to the iron-carbon alloys constituting steel, Portland cement might be a solution of some aluminate in a tri-calcic silicate.

"The problem was approached in the following manner: Clinkers were made from pure chemicals, silica, alumina and lime, in the proportions found in industrial clinker. In order to obtain these proportions it was necessary to determine what the molecular ratios between silica, alumina and its chemical equivalent, iron oxide, and lime and its chemical equivalents, the magnesia and alkalies, were. Fortunately there are in existence two very exact analyses of industrial clinker which will serve for the purpose. If, in these analyses, the weight per cent. of each constituent is divided by the molecular weight of this constituent, that is to say, by its combining number, the quotient will give the relative number of molecules of the different substances in the clinker. It is also possible by adding the molecular proportions of alumina and iron together and of all the bases together, to discover the relation of silica, alumina and iron oxides, these being known as R_2O_3 bases, but here acting as acids, and the lime and other bases, known as the MO bases, to each other and by dividing each of these ratios by such a figure as will maks that for silica equal to 1.0 to express this still more simply. It is also possible from these ratios to calculate, by multiplying them by the atomic weight of silica, alumina and lime, the proportions by weight and the precentages of each of these materials which it is necessary to use in order to produce a pure clinker having the same basicity and molecular ratio as the industrial clinker, but in which the unessential elements are absent. In this process, however, it is necessary to deduct the amount of lime which is present in combination with sulphuric acid, as this plays no part in the formation of the clinker."

Mr. Richardson goes into the proportions of the various elements of cement clinker very fully, and the reader must be referred to the original paper for the tabulated results of his researches. It is sufficient to state here that the microscopic examination fully confirms the solution theory, and makes clear a number of points which were unexplained by the chemical theory.

By studying the physical constitution of various clinkers the effect of temperatures of burning, rates of cooling, and fineness of grinding may be determined very closely, and a comparison of the appearance of the clinker with the actual behaviour of the product made a means of improvement of the product, or a repetition of certain desirable properties.

There has been much controversy and disagreement among makers and users of cements as to the relative values of different grades and kinds, and there has been a tendency to rely upon chemical composition or method of manufacture in the determination of the various grades. It is evident that the true method is that advocated by Mr. Richardson, and that henceforth the microscope will become the criterion of character and value with cement as with steel.

It is apparent that no one method of study or system of examination should be considered sufficient for any material of construction, as there is no logical reason for assuming that the strength bears any definite relation to the chemical composition, to the physical structure, or to any one selected class of properties which it may be found convenient to observe. We have grown so accustomed to the idea that because certain substances are alike in some respects they are alike in all others, that it is hard to realize that this may not be so, but experience is teaching the observant engineer that he should exhaust every means which science has placed at his disposal for the study of the materials with which his work must be done. It is only by such care and thoroughness that rational methods can be developed to replace the older empirical ones.

THE BEHAVIOUR OF STEEL UNDER VIBRATION.

PRELIMINARY NOTES ON THE FRACTURE OF STRUCTURAL STEEL UNDER ALTERNATING STRESSES.

Prof. J. O. Arnold—British Association for the Advancement of Science.

AMONG the important papers presented before the recent meeting of the British Association for the Advancement of Science we may call especial attention to one read before the Engineering Section by Professor J. O. Arnold upon the question of the fracture of structural steel under alternating stresses.

"The efforts of steel metallurgists and engineers to obtain scientific control over the mechanical properties of steel for structural engineering purposes, although attended with much success, have nevertheless presented certain unfortunate features of failure. Thirty or forty years ago it was claimed, apparently with reason, that if the chemical constituents of mild steels were identical their mechanical properties were necessarily similar. But, as experience extended, it soon became evident that steels registering practically the same chemical analyses gave astoundingly different mechanical tests.

"The next stage of research led to the enunciation of the generally accepted idea that steels having a good chemical composition, correlated with satisfactory tensile and bending tests, were thoroughly reliable. But the advent of high speeds placed engine parts under rapidly alternating tensile and compression stresses, the reversals being in some instances at the rate of 800 per minute. Under these new conditions the sense of security ensured by a good chemical composition and satisfactory static tests was rudely disturbed by the fact that steel, in a relatively small number of cases was liable to fracture far below its elastic limit, more after the manner of glass than of a ductile metal."

It was in consequence of just such anomalies as these that attention was drawn to the value of the microscopic method of studying the physical properties of steel, and by the methods of metallography much has been learned about the relations of chemical and physical constitution upon the resistance of the metal. Professor Arnold admits, however, that after fifteen years of research, the microscope has failed to solve the mystery of steel in this particular matter.

The importance of this question will appear when it is understood that the problem is the determination of the cause and prevention of the failure of steels, normally possessing great toughness and ductility, when these are subjected to continuous vibration and alternation of stresses. These are the actual working conditions existing in very many important structures, and the failure in actual service may mean great loss both of life and property, so that the problem possesses great importance, both from a scientific and economic point of view.

As an example in the subject Professor Arnold cites the failure under the hydraulic test, of a boiler plate, which when subjected to chemical analysis and to the testing machine gave entirely satisfactory results. Under the microscope the structure showed a distinct and unusually sharp segregation of the pearlite and ferrite, the latter being angular and intensely crystallized. It was also large in pattern and frequently occurred in those long white lines rich in sulphur and phosphorus, which are technically known as "ghosts." It was at first thought that the sharp crystallisation might be regarded as an effect due to the causes which also produced the effect of brittleness, but this opinion was decisively negatived by subsequent experiments.

In order to investigate the subject further Professor Arnold has constructed at Sheffield University College a special form of testing machine for subjecting the test piece to severe alternating stresses, slightly beyond the elastic limit. The present machine, which is a preliminary one, records the number of vibrations, which can be varied at will, but in a future series of tests it is intended that a record shall also be made of the energy expended per test piece, by means of a delicate integrating wattmeter.

This method of testing, which practically

carries out the almost impracticable Wöhler test in one or two minutes, has already thrown important light on the obscure phenomena under investigation, and has exhibited remarkable delicacy. At the present time the results obtained appear to warrant Professor Arnold in making certain preliminary statements.

"In preliminary tests on standard English acid open-hearth boiler-plate steel the remarkable fact was noted that in all probability *the resistance of structural steel to rupture under rapidly alternating stresses is inversely proportional to the rate of alternation.* This law, if fully established by the exhaustive experiments now being carried on at the Sheffield College, demands careful attention from every engine designer."

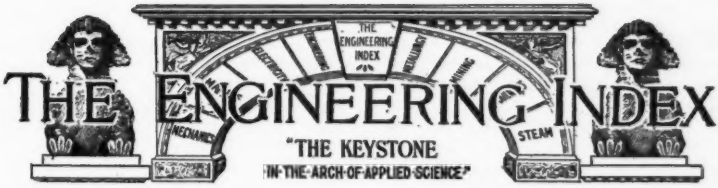
Professor Arnold tabulates some of his results, showing the data upon which he bases these conclusions, and also calls attention to the manner in which certain erratic results were explained by the assumption that one side of the plate under test was brittle and the other tough, a matter now under investigation. Experiments upon attempts to remove the brittleness caused by alternating stresses by annealing revealed some curious results. In the first place it appears that when a steel has assumed decisive brittleness in alternation it cannot be restored by heat treatment of any kind short of remelting. The injury to this especial steel was on one side of the plate, and hence was due to unskilful re-heating of the ingot and not to an improper casting temperature, since the latter must necessarily have affected every portion of the plate. Further, it appears that the microstructures of specimens both of the brittle and the tough steels, were in all respects identical, though that of each pair varied with the heat treatment to which they had been subjected.

Professor Arnold further discusses some investigations made by him upon a test piece of mild steel, bent to a radius of about two feet, so that the outer side was subjected to a marked tension and the inner to compression. Such a piece, subjected to alternations of 266 per minute, showed that, in regard to resistance to fracture, the portion of the plate in tension was inferior to that in compression, while the steel about the neutral line was superior to that next to the inner radius.

These experimental investigations, of which the present report is but a preliminary one, appear to be of much importance, and when completed will doubtless furnish reliable data of great value to the designing engineer. The fact that they have been undertaken by such a man as Professor Arnold, in the course of the work of the mechanical laboratory of the Sheffield College, demonstrates the usefulness of such a laboratory, and proves that such an institution may be made of much more use than the mere repetition of well-known phenomena for the instruction of students. There is no doubt that instruction and research may be carried along together to the joint benefit of the students and the engineering profession at large, and in this respect Professor Arnold has demonstrated, not only some important facts with regard to the behaviour of steel, but also as to the right use of the facilities which have been placed at his disposal.

In this connection the results which have been shown as to the injurious influence of alternating stresses upon materials of construction should emphasize the importance of avoiding such stresses whenever possible. In this respect the growing interest in machines operating solely by continuous motion, such as steam turbines, centrifugal pumps, rotary blowers, etc., is of importance, and it may be that the true way of preventing the dangers from alternating stresses is to strike the evil at its source and adopt, whenever possible, such designs in which reciprocating and alternating motions, especially at high speeds, may be abandoned.

Already the difficulties of dealing with the forces occurring in connection with rapidly alternating movements have been encountered by the engineer, and the questions of counterbalancing repicrocating masses and the prevention of excessive vibration have for some time formed the subject of study and experiment. When to these are added the internal stresses and weakening effects shown by Professor Arnold, it is apparent that there are many good reasons for using pure rotary motion.



The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger division of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX.

CIVIL ENGINEERING 125
ELECTRICAL ENGINEERING 132
INDUSTRIAL ECONOMY 138
MARINE AND NAVAL ENGINEERING.... 138
MECHANICAL ENGINEERING 140
MINING AND METALLURGY..... 147
RAILWAY ENGINEERING 152
STREET AND ELECTRIC RAILWAYS..... 155

CIVIL ENGINEERING

BRIDGES.

Amsterdam.

The Operation of the New Bridge over the Amstel at Amsterdam (Bewegingsinrichtingen der Nieuwe Amstelbrug te Amsterdam). F. C. Dufour. With illustrations of the new arched bridge, and details of the operation of the double bascule draw span. 3500 w. De Ingenieur—June 11, 1904. No. 64475 D.

Arch.

The Bridge over the Syra Valley at Plauen in Voigtland (Die Syratalbrücke in Plauen i. V.) H. Fleck. A detailed account of the construction of a highway bridge at Plauen near Leipzig. The single masonry arch is of 90 metres span. Two articles. 2500 w. Deutsche Bauzeitung—July 16, 20, 1904. No. 64440 each B.

Design of a Fixed-Ended Arched-Rib Highway Bridge. Prof. Chas. Derleth, Jr. Calculations, stress sheets and general drawings for a steel bridge which was one of the designs submitted for a bridge to Goat Island, Niagara River. 2 Plates. 6000 w. Cal Jour of Tech—May, 1904. No. 64635 C.

We supply copies of these articles. See page 158.

Bascule.

The Division Street Bascule Bridge, Chicago. Description of bridge, with illustration, and of the operation of each leaf independently by electric motors. 800 w. Eng Rec—Aug. 20, 1904. No. 64501.

Concrete.

The New Concrete Arch Bridge over the Etsch at Forst (Die Neue Gewölbte Betonbrucke über die Etsch bei Forst). C. Haberkalt. Describing a concrete arch with hinges at the springings, 31 metres span over the Etsch in the Tyrol. 2500 w. 2 plates. Oesterr Wochenschr f d Oeff Baudienst—July 2, 1904. No. 64471 D.

Drawbridge.

Replacing a Double-Track Drawbridge. Illustrated description of the new bridge across the Menominee River, at Milwaukee, Wis. 2000 w. Eng Rec—July 30, 1904. No. 64180.

Ferry Bridges.

Flying Ferries. Novel Bridge Construction. General description of transporter, or ferry, bridges, and of those over the Manchester Ship Canal and the Mersey River and over the Usk, at Newport, Monmouthshire. 1200 w. Ir & Steel Trds Jour—Aug. 6, 1904. No. 64694 A.

Suspension Ferry over the Loire River at Nantes, France. B. H. Ridgely. Brief illustrated description of ferry or transfer bridges at Nantes and at Newport, England. 1000 w. R R Gaz—Vol. XXXVII, No. 11. No. 64625.

Fraser River.

The Erection of the 232-Foot Triangular Span of the Fraser River Bridge. Illustrated description of erection of the unique spread span of the double-deck railroad and highway bridge at New Wesminster, B. C. 1800 w. Eng Rec—Aug. 13, 1904. No. 64398.

Girders.

Principles of an Analytical Theory of the Action of External Forces on a Continuous Girder (Grundlage für eine Analytische Theorie der Aeusseren Kräfte der Kontinuierlichen Träger). Nikolaus v. Szüts. A mathematical investigation, taking into account the resistance of the piers to bending. 3000 w. Zeitschr d Oesterr Ing u Arch Ver—July 15, 1904. No. 64414 D.

The Continuous Girder upon Elastic Yielding Piers (Der Durchgehende Träger auf Elastisch Senkbaren Stützen). L. Geusen. A graphical examination of the distribution of forces in a continuous girder when the supports are not rigid. 1800 w. Zeitschr d Ver Deutscher Ing—July 23, 1904. No. 64404 D.

Newburyport.

The Merrimac River Bridge at Newburyport. Illustrated description of highway bridge with four fixed spans and one draw span. The large cylinders for piers were grouted in place by air pressure. Also, editorial. 3500 w. Eng Rec—Aug. 20, 1904. No. 64504.

Reinforced Concrete.

A Skew-Span Double-Track 54-Foot Reinforced Concrete Arch. Describes a bridge in progress at Jackson St., Newark, N. J., for carrying the two main tracks of the Central Railroad of New Jersey. 2000 w. Eng Rec—Aug. 16, 1904. No. 64282.

Concrete-Steel Bridges at Dayton, O. Photographs and drawings with data showing the details of construction for two similar bridges. 2800 w. Munic Engng—Aug., 1904. No. 64262 C.

Suspension Bridges.

Theory and Formulas for the Analytical Computation of a Three-Span Suspension Bridge with Braced Cable. Leon S. Moisseiff. Mathematical discussion and diagrams. 5 Plates. 5000 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64585 E.

A Rational Form of Stiffened Suspension Bridge. Gustav Lindenthal. Showing the advantages of this form, and describing particularly the Manhattan Bridge over the East River, New York. Illustrations and diagrams. 3 Plates. 2500 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64584 E.

General Methods for the Calculation of Statically Indeterminate Bridges, as Used in the Check Calculations of Designs for the Manhattan Bridge and the Blackwell's Island Bridge, New York. Frank H. Cilley. Mathematical discussion, with diagrams. 8000 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64583 E.

A Light 510-Foot Suspension Bridge. Illustrates and describes a bridge across the Kanawha valley, near Coperton, W. Va. 2000 w. Eng Rec—Aug. 6, 1904. No. 64284.

Sydney.

Sydney Harbour Bridge. Illustrated description of designs submitted for a bridge with a main span of 1,350 ft., 170 ft. above the water, and a total length of 3,000 ft. 3000 w. Engr, Lond—Aug. 12, 1904. No. 64526 A.

Trestles.

Pile and Timber Trestle Bridges on the Santa Fé. Extracts and illustrations from paper by A. F. Robinson in Bulletin No. 53 of the American Railway Engineering and Maintenance of Way Association. 2200 w. R R Gaz—Vol. XXXVII, No. 9. No. 64380.

Viaduct.

The Avignon Viaduct. Daniel Bellet. Illustrated detailed description of a via-

We supply copies of these articles. See page 158.

duct connecting two stations on the Paris-Lyons-Mediterranean Railway, at Avignon. 1000 w. Trac & Trans—Aug., 1904. No. 64349 E.

Vienna.

The Rebuilding of the High Bridge over the "Tiefen Graben" in Vienna (Der Umbau der Hohen Brücke über den Tiefen Graben in Wien). Karl Christl. Illustrated description of a viaduct carrying an important city street over an old depressed quarter. 2000 w. 3 plates. Oesterr Wochenschr f d Oeff Baudienst—June 11, 1904. No. 64466 D.

CONSTRUCTION.

Building Collapse.

The Collapse of a Building During Construction. Discussion on paper by H. de B. Parsons on the Hotel Darlington disaster in New York. 10000 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64586 E.

Building Construction.

The New York "Times" Building. An illustrated account of the new building at Broadway and 42nd Street, New York. 2500 w. Stevens Ind—July, 1904. No. 64343 D.

Concrete Surfaces.

Facing and Finishing Exposed Concrete Surfaces. Extracts from a forthcoming book on "Reinforced Concrete" by A. W. Buel and Charles S. Hill. 6000 w. Eng News—Aug. 25, 1904. No. 64608.

Dams.

An Earth Dam with Loam Core, at Clinton, Mass. Illustrated description of the south dike of the Wachusett Reservoir, 3,000 ft. long, 620 ft. wide and 60 ft. high. Serial. 1st part. 1800 w. Eng Rec—Aug. 20, 1904. No. 64510.

Concrete Dam and Concrete Steel Subway for Walter Baker & Company, Limited. Drawings and description of interesting concrete work. 1500 w. Eng Rec—Aug. 6, 1904. No. 64278.

Lake Cheeseman, Dam and Reservoir. Discussion on paper by Charles L. Harrison and Silas H. Woodard. 9000 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64591 E.

The Gatun Dam. Discussion on paper by C. D. Ward on a dam for controlling the Chagres River, Panama. 1600 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64589 E.

Earth Pressures.

Lateral Earth Pressures and Related Phenomena. Discussion on paper by E. P. Goodrich. 4000 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64590 E.

Embankment.

Highway Embankment Across Tidal Flats at Lynn, Mass. Illustrated description of a pleasure highway across the tidal flats and marshes near the mouth of the Saugus River, which requires an embankment averaging 12 or 13 feet in height. 1800 w. Eng Rec—Aug. 6, 1904. No. 64281.

Fireproof Construction.

Lessons of the Baltimore Fire. Abstract of an address by Capt. J. S. Sewell, Corps of Engineers, U. S. A., before Nat'l Board of Fire Underwriters, particularly on the construction of buildings so as to protect them against fire from outside. 2000 w. Eng Rec—Aug. 20, 1904. No. 64505.

The Effects of the Baltimore Fire. W. N. Hazen. General discussion of the effects of this great fire on the buildings, fireproof and otherwise, with illustrations. 6500 w. Pro Engrs' Soc of W Pa—May, 1904. No. 64631 D.

Reinforced Concrete.

A Statical Investigation of a Curved Prismatic Body of Reinforced Concrete (Statische Untersuchung eines Einfach Gekrummten, Stabförmigen Verbundkörpers). Prof. Ramisch. A mathematical study showing the action of forces to effect bending. 3500 w. Oesterr Wochenschr f d Oeff Baudienst—July 9, 1904. No. 64472 D.

A Study of the Properties of Reinforced Concrete (Een Onderzoek naar de Eigenschappen van Gwapend Beton). A. C. C. G. van Hemert. Describing tests upon reinforced concrete beams, with determinations of coefficients for various combinations. 7500 w. De Ingenieur—June 4, 1904. No. 64474 D.

Reinforced Concrete Construction in a Commercial Sand Plant. Illustrates and describes the interesting features of a plant at New Brighton, Staten Island. 3300 w. Eng Rec—July 30, 1904. Serial. 1st part. No. 64179.

Tests of Reinforced Concrete Beams. Prof. Arthur N. Talbot. Illustrated paper before the American Society for Testing Materials, giving description and results of tests made at the University of Illinois. Table: Diagrams. 4000 w. Eng News—Aug. 11, 1904. Also, Eng Rec—Aug. 13, 1904. No. 64364.

The Compressive Resistance of Hooped Concrete (Die Druckfestigkeit des Umschnürten Betons). Dr. R. Saliger. A mathematical examination of the strength of concrete pillars wrapped with wire, according to the method of Considère. 2000 w. Oesterr Wochenschr f d Oeff Baudienst—June 18, 1904. No. 64469 D.

Suggestions for Steel-Concrete Con-

struction. John C. Anderson. Paper before the Louisiana Engineering Society, giving brief general discussion, with illustrations. 800 w. Jour Assn of Engng Socs—July, 1904. No. 64580 C.

See also Civil Engineering, Bridges.

Road-Making Machinery.

The Management of Road Locomotives. T. C. Aveling. Read before the Midland Munic. Officers' Assn. Points for the maintenance of road-making machinery. 2500 w. Quarry—Aug., 1904. No. 64340 A.

Steel-Pile Caisson.

A Steel-Pile Caisson at Omaha. Description, with illustration, of a cofferdam constructed with Friestedt interlocking channel bar piles. 1000 w. Eng Rec—Aug. 1, 3, 1904. No. 64396.

Timber-Concrete.

Adhesion of Timber Piles to Concrete. Translated from an article by M. E. Rousel in the *Annales des Travaux Publics de Belgiques*, giving an account, with diagrams, of experiments made on a testing machine, conforming to actual practice. 2000 w. Engr, Lond—Aug. 12, 1904. No. 64528 A.

Tunnels.

Progress on the Harlem River Tunnel of the New York Rapid Transit Railroad. Illustrated account of work on this double-track tunnel, 1,500 ft. long, part being a twin-tube cast-iron shell enclosed in concrete. 4000 w. Eng Rec—Aug. 20, 1904. No. 64500.

Some Recent Works of Railway Tunnel Improvement. Describes the relining and change of grade in the Winston tunnel, and the opening up of the Arion tunnel. Ills. 1500 w. Eng News—Aug. 4, 1904. No. 64249.

The Construction of the Simplon Tunnel (Der Bau des Simplon-Tunnels). C. J. Wagner. A detailed review of the work for the year from January 1, 1903, to January 1, 1904. 10000 w. 2 plates. Oesterr Wochenschr f d Oeff Baudienst —July 30, 1904. No. 64473 D.

Hot Springs and the Simplon Tunnel. An explanation of the conditions which have caused the interruption of this work at the Swiss side. 1800 w. Engr, Lond —Aug. 19, 1904. Serial. 1st part. No. 64664 A.

Workmen's Dwellings.

See Industrial Economy.

MATERIALS OF CONSTRUCTION.

Cement.

Blast Furnace Slag and Cement in Connection with the Theory of Zulkowski (Hochofenschlacke und Zement im Lichte der Zulkowskischen Theorie). C. Canaris, Jr. An examination of the chemical properties of furnace slag and its combinations, comparing slag cement and Portland cement from the chemical standpoint. 5000 w. Stahl u Eisen—July 15, 1904. No. 64430 D.

The Constitution of Portland Cement from a Physico-Chemical Standpoint. Clifford Richardson. Address before the Association of Portland Cement Manufacturers, discussing the microscopical examination and chemical analysis of cements, showing that latter is not a sure test of their value. Tables. 7000 w. Eng Rec—Aug. 13 & 20, 1904. Also Eng News —Aug. 11, 1904. No. 64366.

Cement Works.

The Dexter Portland Cement Works. Illustrated description of mills in Pennsylvania. 2000 w. Eng Rec—Aug. 6, 1904. No. 64280.

Clays.

Clays and Their Properties. An editorial on the importance of the investigations carried on in the Division of Tests of the U. S. Dept. of Agriculture, summarizing the results, and showing the behavior of the material. 1300 w. Eng Rec —July 30, 1904. No. 64182.

Fireproofing.

Ferrell's Apparatus and Process for Fireproofing Wood. Report of the Committee on Science and the Arts on the invention of Joseph L. Ferrell. Ills. 1200 w. Jour Fr Inst—Aug., 1904. No. 64359 D.

Floor Test.

A Method of Measuring Deflections in Floor Tests. Edward Godfrey. Brief illustrated description of simple method. 350 w. Eng News—Aug. 25, 1904. No. 64613.

Paint.

Tests of Paint. Extracts from a report by Dr. Charles B. Dudley to the American Society for Testing Materials, on preservative coatings for iron and steel and methods of testing them. 2200 w. Eng Rec—Aug. 20, 1904. No. 64508.

MEASUREMENT.

Barometer.

A Portable Recording Barometer (Baromètre Altimétrique Enregistreur de Poche). An illustrated description of the Périllat recording barometer, which enables a profile of the country traversed to be made. 800 w. Génie Civil—July 16, 1904. No. 64422 D.

Mine Surveying.

Surveying and Mapping of Flat Coal Mines. Charles H. Thompson. General discussion and practical directions. 2800 w. Eng & Min Jour—Aug. 25, 1904. No. 64620.

We supply copies of these articles. See page 158.

Surveying.

Surveying at the German Municipal Exhibition at Dresden (Das Vermessungswesen auf der I. Deutschen Stadtausstellung in Dresden). Dr. Hans Löschner. With numerous illustrations showing improvements in methods of surveying, levelling, etc., with especial reference to municipal work. Two articles. 6000 w. Zeitschr d Oesterr Ing u Arch Ver—July 15, 22, 1904. No. 64413 each D.

Turnouts.

See Railway Engineering, Permanent Way.

MUNICIPAL.

Asphalt Plants.

Municipal Asphalt Plants. General description, with costs, of plants at Winnipeg and Detroit, visited by Andrew Rosewater, city engineer of Omaha, on a tour of inspection. 1000 w. Eng Rec—Aug. 20, 1904. No. 64503.

Pavements.

Specifications for Brick Pavement. Gives the principal points in the new specifications for Akron, O. The pavements are of brick. 3000 w. Munic Jour & Engr—Aug., 1904. No. 64245 C.

Paving.

Problems of Street Paving. Extracts from a report made by John W. Alvord considering various problems and proposed methods of solutions for the city of Chicago. Diagrams and tables, with discussion of materials. 5800 w. Munic Engng—Aug., 1904. No. 64263 C.

Pipe Galleries.

Pipe Galleries for New York. James C. Baylis. Discusses the effect on pavements of the frequent excavations, and of gas leakage, and the lessons to be learned from the experience of foreign cities. 2500 w. Munic Jour & Engr—Aug., 1904. No. 64244 C.

Rotterdam.

Municipal Rotterdam. Descriptions, with illustrations, of sewerage, water supply, street cleaning and other features. 1000 w. Public Works—Aug. 15, 1904. No. 64649 D.

Sewage Disposal.

Some Notes on the Cost of Cinders for Sewage Filter Beds. Ernest McCullough. Practical points on the cost and manipulation of cinders. 2200 w. Eng News—Aug. 18, 1904. No. 64369.

Small Sewage Disposal Plants. Illustrated description of four British plants. 1600 w. Engr, Lond—Aug. 5, 1904. No. 64521 A.

The Sewage Fields of Freiburg i. B. (Das Rieselfeld für die Stadtische Kanalwasser von Freiburg i. B.). Dr. P. Kresnik. An illustrated description of the sewage farms in operation since 1891. 2000 w. 1 plate. Oesterr Wochenschr f d Oeff Baudienst—June 25, 1904. No. 64470 D.

Seaside Sewage Disposal. Arthur J. Martin. Abstract of a paper before the Royal Institute of Public Health (British), giving a general review of sewage disposal of seaside towns. 1500 w. Eng News—Aug. 25, 1904. No. 64607.

Sewage Purification. C. M. Ginther. Remarks on methods of purification with a brief illustrated description of the very successful plant installed at the Eastern Indiana Hospital for the Insane. 1500 w. Sci Am Sup—Aug. 27, 1904. No. 64652.

The Glasgow Main Drainage System. A. B. McDonald. Illustrated description of a very large sewerage and sewage disposal system. 2500 w. Public Works—Aug. 15, 1904. No. 64642 D.

Standards of Purity for Sewage Effluents. Part of a paper by Prof. Dr. Dunbar (Hamburg) read before the Congress of the Sanitary Inst. at Glasgow. Discusses whether we are able to judge by the results of chemical analysis whether sewage freed from suspended matter tends to putrefy. 4500 w. Builder—Aug. 20, 1904. No. 64657 A.

Streets.

The Right to Break Up Streets. Discusses English law upon this subject. 3600 w. Engr, Lond—July 22, 1904. Serial. 1st part. No. 64229 A.

WATER SUPPLY.

Berlin.

The Supply of Berlin with Groundwater (Die Versorgung der Stadt Berlin mit Grundwasser). A review of the proposition to increase the water supply of Berlin, with an estimate of the available ground-water supply. 2500 w. Gesundheits-Ingenieur—July 31, 1904. No. 64420 B.

Birmingham.

Birmingham's New Water Supply. An illustrated detailed description of the whole undertaking. An important engineering work. 4800 w. Engr, Lond—July 22, 1904. No. 64228 A.

Copper Sulphate.

Treatment of a Reservoir of the Butte Water Co. with Copper Sulphate. Eugene Carroll. Description of favorable experience with copper sulphate for destroying vegetable organisms in water supplies; with photo-micrographs and tables. 1500 w. Eng News—Aug. 18, 1904. No. 64373.

Filtration.

An Improved Method for the Bacterial Purification of Water (Nouvelle Contribution à l'Epuration Bacterienne des

We supply copies of these articles. See page 158.

Eaux). MM. P. Miquel & H. Mouchet. Showing the excellent results obtained by filtration through a non-submerged bed of fine sand. 1000 w. Comptes Rendus—July 18, 1904. No. 64442 D.

The Philadelphia Filtration System. General description and plans of the largest filtration system in the world. 4500 w. Eng News—Aug. 18, 1904. No. 64375.

Glasgow.

The Glasgow Water-Works. Robert Wilson. Illustrated description of the Loch Katrine works, aqueducts, service reservoirs, Gorbal works, river supply works and other features. 2000 w. Public Works—Aug. 15, 1904. No. 64646 D.

Meters.

Metered Services. F. G. Kimball. Read before the Am. W.-Wks. Association. A defence of the minimum rate charged when water is sold by meter. 2500 w. Fire & Water—Aug. 27, 1904. No. 64700.

Moorland Water.

Treatment of Moorland Water to Prevent Action upon Lead Pipes. Abstract of a paper by C. C. Smith and E. M. Chaplin before the British Assoc. of Water-Works Engrs., giving account of the treatment of the water supply of Wakefield with carbonate of soda and by other methods. 1400 w. Eng Rec—Aug. 13, 1904. No. 64397.

Pumping Station.

Gainsborough Water-Works. Description of this interesting plant with illustrated details of the pumping station. 1600 w. Engr, Lond—July 29, 1904. No. 64322 A.

Some American Figures on the Operation of Pumping Stations. Items from information relating to a number of large water-works pumping plants in the United States, collected by Will J. Sands. 2200 w. Eng Rec—Aug. 6, 1904. No. 64283.

Purification.

The Purification of Water. Prof. John M. Ordway. Paper before the Louisiana Engineering Society, giving a general review. 3000 w. Jour Assn of Engng Socs—July, 1904. No. 64581 C.

Reichenberg.

The Waterworks of the City of Reichenberg (Das Wasserwerk der Stadt Reichenberg). U. Huber. A detailed account of the new works and pumping stations for the water supply of Reichenberg, Bohemia. The supply is obtained from a number of small streams. 7500 w. 6 plates. Oesterr Wochenschr f d Oeff Baudienst—June 4, 1904. No. 64465 D.

Sedimentation.

On Sedimentation. Discussion on paper by Allen Hazen on water purification. 2000 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64588 E.

Softening Water.

Notes on the Softening of Iowa Well Waters. Prof. Nicholas Knight. A condensed record of investigations in the chemical laboratory of Cornell College, Mt. Vernon, Iowa, by C. G. Eldredge. Tables. 800 w. Eng News—Aug. 18, 1904. No. 64376.

Stand-Pipe.

Damage by Ice to the Stand-Pipe at Cobourg, Ont., and the Repairs Thereto. H. C. Hodgkins. Illustrated description of bursting of sheets by water in standpipe freezing, and method of repairing. 700 w. Eng News—Aug. 18, 1904. No. 64367.

Submerged Pipe.

Laying a Submerged Water Pipe at North Tonawanda, N. Y. An illustrated article giving information concerning the methods adopted and difficulties encountered. 2200 w. Eng News—Aug. 4, 1904. No. 64248.

Underground Water.

The Underground Water Circulation. Charles Mortimer Cross. A study of the flow of underground water, giving examples illustrating the action, and explaining vadose circulation and deep circulation. 1200 w. Ores & Metals—Aug. 1, 1904. Serial. 1st part. No. 64259.

Wells.

Open Wells and Turbine Pumps. Dabney H. Maury. Extracts from a lecture before the American Water-Works Association, illustrating and describing wells, well strainers and well sinking at Peoria, Ill., and discussing centrifugal or turbine pumps. Also editorial. 4000 w. Eng News—Aug. 18, 1904. No. 64371.

The Additional Water Supply of Middletown, Ohio. Illustrated description of well construction, with novel arrangement of strainer pipes. 350 w. Eng News—Aug. 11, 1904. No. 64363.

WATERWAYS AND HARBORS.

Belgium.

Navigable Waterways in Belgium. E. Cecil Hertslet. Description of canals and other inland waterways, with traffic statistics, tables and maps. 6000 w. Public Works—Aug. 15, 1904. No. 64647 D.

Canals.

Canal Policy in England. W. M. Acworth. A discussion of the proposed new policy. 2000 w. Ry Age—July 29, 1904. No. 64213.

The Austrian Canal Projects (Die Trassen des Oesterreichischen Kanale). Richard Kuhn. A discussion of the proposed waterways in Austria, including the Danube-Oder canal, the Danube-Moldau canal, and the various auxiliary projects.

We supply copies of these articles. See page 158.

6000 w. Zeitschr d Oesterr Ing u Arch Ver—Aug. 5, 1904. No. 64417 D.

The Pioneer Sault Canal. Charles T. Harvey. An interesting review of the history from the earliest promoting measures in 1857. 7500 w. Marine Rev—Aug. 4, 1904. No. 64265.

Canal Traction.

See Street and Electric Railways.

Dock Crane.

50-Ton Electric Crane. Description and illustration of a revolving, travelling crane, for the Southampton docks. 600 w. Engng—Aug. 12, 1904. No. 64517 A.

Dredge.

Boom Dredge and Conveyors (Drague à Bras et à Transporteurs de Deblais). H. E. Jeanin. Illustrating a special form of ladder dredge with projecting boom, designed for cutting irrigation channels in China. 1500 w. 1 plate. Mem Soc Ing Civ de France—May, 1904. No. 64445 G.

Egypt.

Irrigation Projects in Egypt and the Soudan. Extracts from a report of Sir William Garstin to Lord Cromer, describing projects for regulating the Nile, with map of White Nile region. 2500 w. Engr, Lond—Aug. 12, 1904. No. 64525 A.

Florida Coast.

The Waterway of the Florida Coast Line Canal and Transportation Co. George F. Miles. Illustrated description and map of natural waterways and connecting canals down the east coast of Florida, from Jacksonville to Key West. 2800 w. Eng News—Aug. 25, 1904. No. 64606.

Flow.

Methods of Estimating Stream Flow. John C. Hoyt. Explains the methods in use, illustrating by example. 1000 w. Eng News—Aug. 4, 1904. No. 64252.

Some Flood Discharges and Values of "n" in Kutter's Formula. R. H. Anderson. Explains method of making computations for McCall's Ferry on the Susquehanna River. 800 w. Eng News—Aug. 4, 1904. No. 64251.

Heysham Harbor.

Gas-Driven Electrical Plant at Heysham Harbor, England. Description, with illustrations, of Mond gas producer and gas-driven electric plant for lighting and supplying power for cranes, lifts, etc. 700 w. Elect Wld & Engr—Aug. 13, 1904. No. 64531.

Midland Railway Company's Steamship Service. Begins an illustrated detailed description of the construction of Heysham Harbor, with remarks on the promotion of the scheme and matters related. 2700 w. Engng—July 29, 1904. Serial. 1st part. No. 64321 A.

Hydraulic Lift.

The Hydraulic Lift Lock in the Trent Canal. John McClelland Bulkley. Illustrated description of the new lock at Peterborough, Ontario, with a lift of 65 feet, designed for 800-ton barges. Also, editorial. 4500 w. Eng Rec—Aug. 13, 1904. No. 64395.

Irrigation.

New Irrigation Projects for Egypt and the Soudan. Considers the future requirements of Egypt and the Soudan. 5400 w. Builder—Aug. 20, 1904. No. 64656 A.

Valparaiso.

The Harbor of Valparaiso (Le Port de Valparaiso). Ch. Dantin. An illustrated review, showing the present condition of the port, and the plans for its expensive improvement. 3500 w. 1 plate. Génie Civil—July 16, 1904. No. 64421 D.

MISCELLANY.

Estimates.

See Industrial Economy.

Land Drainage.

Tile Drain Laying. 2nd Prize Paper. F. N. Pitkin. Describes methods, instruments used. Ills. 5200 w. Brick—Aug., 1904. Serial. 1st part. No. 64260.

Landscape Architecture.

Landscape Architecture. Stephen Child. Lecture before the Boston Society of Civil Engineers, giving a general account of the subject, with illustrations. 2800 w. Jour Assn of Engng Socs—July, 1904. No. 64579 C.

Landslide.

A Phenomenal Landslide. Discussion on paper by D. D. Clarke on landslide involving reservoirs near Portland, Ore. 1400 w. Pro Am Soc of Civ Engrs—Aug., 1904. No. 64587 E.

St. Louis Exposition.

A Review of the Engineering Exhibits at the St. Louis Exposition. General review. 2500 w. Eng News—Aug. 11, 1904. No. 64365.

Sand Dunes.

The Problem of the Dune. F. B. Kellogg. Methods of arresting the encroachments of sand, by growing beach grass and otherwise. 2000 w. Cal Jour of Tech—May, 1904. No. 64640 C.

Shovel.

The Increasing Capacity of Power Shovels. George E. Walsh. Remarks on the great increase in capacity during the last year or two, and the effect on mining, excavating of canals, and general excavation work. 1400 w. Ir Trd Rev—Aug. 4, 1904. No. 64255.

We supply copies of these articles. See page 158.

ELECTRICAL ENGINEERING

COMMUNICATION.

Alaskan Cable.

Completion of the Alaskan Cable. Article reprinted from *Telegraph Age*, giving an account of the laying of a cable from Skagway to Seattle, and telling of other telegraph and wireless projects in Alaska. 1500 w. Elec Rev, N. Y.—Aug. 13, 1904. No. 64538.

Automatic Telephone.

The Strowger Automatic Telephone System (Het Automatisch Telephonsystem van Strowger). N. Heinzelmann. A fully illustrated description of the instruments and switchboard, and an account of the operation of the system in the United States. 6000 w. 1 plate. De Ingenieur—June 25, 1904. No. 64477 D.

Exchange.

Multiple Switchboard Exchange at Neustadt a. d. Haardt (Vielfach-Umschalteeinrichtung in Neustadt a. d. Haardt). J. Jacob. A very complete description of a modern exchange with lamp signals, central battery, etc. Two articles. 8000 w. Elektrotech Zeitschr—July 14, 21, 1904. No. 64447 each B.

Fault Location.

See Electrical Engineering, Measurement.

Glasgow Telephones.

The Glasgow Municipal Telephones. A. R. Bennett. Illustrated description of the principal features of a system with over 8,000 working lines. 2500 w. Public Works—Aug. 15, 1904. No. 64644 D.

Glasgow Municipal Telephone System: Estimates and Results Compared. Herbert Laws Webb. Showing that the original estimates of cost and size of plant have been greatly exceeded. Curves. 1600 w. Elec Rev, Lond—Aug. 5, 1904. No. 64551 A.

Janus Telephone.

The Janus Telephone System. Dr. Alfred Gradenwitz. Illustrates and describes this system which enables each telephone of a private network to be used simultaneously with those belonging to the system of the telephone company. 600 w. Sci Am Sup—Aug. 27, 1904. No. 64655.

Railway Telephones.

See Railway Engineering, Conducting Transportation.

Ship Telegraph.

See Marine and Naval Engineering.

Space Telegraphy.

A Novel Wave Meter for Wireless Telegraphy. An illustrated description of the "multiplier rod" designed by Prof. Slaby, explaining the principle underlying the apparatus. 1200 w. Sci Am—Aug. 6, 1904. No. 64254.

Synthetic Wireless Telegraphy. A. Frederick Collins. Describes a synthetic transmitter and receiver which the writer considers would combine all the essential improvements of all workers in this field. 2800 w. Elec Wld & Engr—July 30, 1904. No. 64237.

The Application of Space Telegraphy to Moving Trains (Ueber die Anwendung der Drahtlosen Telegraphie in Fahrenden Zugen). Wilhelm Biscan. Describing successful experiments in communicating with moving trains on the Aussig-Teplitz railway. 2500 w. 2 plates. Oesterr Wochenschr f d Oeff Baudienst—June 18, 1904. No. 64400 D.

The Government Wireless Report. Abstract of U. S. Navy Dep't report, recommending that the navy have control of all the wireless systems along the coasts of the United States and its outlying possessions. 700 w. Elec Wld & Engr—Aug. 20, 1904. No. 64533.

Telephone Cable.

Economical Features of the Austin Telephone Company's All-Cable Plant, Austin, Minn. Illustrated description of an aerial telephone cable plant, and other features of the equipment of the Austin exchange. Also editorial. 1800 w. Elec Wld & Engr—Aug. 20, 1904. No. 64536.

Telephone Service.

The Relation of Telephone Traffic to Efficient Service. Howard S. Knowlton. Discussion of details of telephone service, with traffic curves. 4000 w. Elec Wld & Engr—Aug. 13, 1904. No. 64530.

Telephony.

The Evolution of Telephonic Protective Apparatus. Charles H. Coar. Discusses the various devices to protect telephone lines not only from lightning, but against other destructive currents. States the qualifications demanded by some of the larger companies. 2500 w. Elec Wld & Engr—July 30, 1904. No. 64236.

Wireless Telephony by Use of the Properties of Selenium (Draadlooze Telefonie en de Eigenschappen en Toepassingen van Selenium). A. H. Opten Noort. Discussing the experiments of Simon, Duddell, Ruhmer and others in the transmission of speech without wires. Two articles. 7500 w. De Ingenieur—June 18, 25, 1904. No. 64476 each D.

We supply copies of these articles. See page 158.

DISTRIBUTION.

Cables.

The Computation and Determination of Self-induction and Current Charge of Single and Polyphase Cables (Zur Berechnung und Experimentellen Bestimmung der Selbstinduktion und Stromrückleitung von Einphasen und Drehstromkabeln). Leo Lichtenstein. Substituting an ideal conductor in place of the actual one, for purposes of calculation. Two articles. 6000 w. Zeitschr f Elektrotechnik —July 31, Aug. 7, 1904. No. 64459 each D.

Conductors.

The Computation of Simple Conductor Systems (Ueber die Berechnung von Leitungen ohne Knotenpunkte). Ernst Kronstein. Developing formulas for simple conductors, or feeder lines. 2500 w. Zeitschr f Elektrotechnik—July 17, 1904. No. 64457 D.

"Earths."

The Localization of "Earths" on Feeders and Networks. Horace Boot. Describes the method which the writer has found the best, giving some results. 1000 w. Elec Rev, Lond—July 22, 1904. No. 64225 A.

Four-Wire.

Some Experiences in the Regulation of a Three-Phase, Four-Wire, Mixed Distribution. C. W. Hutton. Paper before the Pacific Coast Electric Transmission Assoc., giving an account of troubles and remedies with a 200-volt electric distribution system in Sacramento, Cal. Voltage curves. 1000 w. Jour of Elec—Aug., 1904. No. 64561 C.

House Fittings.

Switches and Fuses for House Use (Hausanschlusssicherungen with Feuersicheren Patronen). W. Klement. Illustrating a variety of fittings as made by the Siemens-Schuckert Works for house wiring. 6000 w. Elektrotech Zeitschr—July 14, 1904. No. 64446 B.

Line Construction.

New System of Wire Fixing and Protecting Apparatus for Overhead Electric Light and Power Wires and Cables. Illustrates and describes the system of M. N. K. Astafieff and the devices he adopts for holding the wires, coupling them together, and giving the necessary fuse protection. 1700 w. Elec Wld & Engr—Aug. 6, 1904. No. 64333.

Mains.

A Method of Laying Bare Underground Mains. Illustrated description of the "simplified" solid system. The insulating compound is composed of refined carbolite. 2200 w. Elect'n, Lond—Aug. 19, 1904. No. 64674 A.

Switches.

Long-Distance Switches (Ueber Fernschalter). Fr. Lindenstruth & O. Forster. Illustrating details of switches to be operated electrically at a distance, employing a variety of contact breakers. 2500 w. Elektrotech Zeitschr—July 28, 1904. No. 64451 B.

Long-Distance Switches. F. Lindenstruth and O. Forster. Translation of an article in *Elektrotechnische Zeitschrift.* Considers the construction of certain long-distance switches which can be operated by hand or automatically. Ills. 1500 w. Elec Engr, Lond—Aug. 19, 1904. Serial. 1st part. No. 64669 A.

Transformers.

Notes on Transformer Design (Ueber den Entwurf von Transformatoren). Arthur Müller. Deriving formulas for the most efficient proportion of iron cores and coils. 2000 w. Zeitschr f Elektrotechnik —July 17, 1904. No. 64456 D.

ELECTRO-CHEMISTRY.

Batteries.

Storage Batteries. A discussion of the treatment they should receive, giving notes based on long experience. 2800 w. Elec Rev—July 22, 1904. No. 64226 A.

The Historical Development of the Secondary Element (Die Geschichtliche Entwicklung der Sekundär-Elemente). Otto Hildebrand. A review of the various forms of electric storage devices, from the observations of Gautherot, in 1802, down to the present time. 2500 w. Elektrochem Zeitschr—August, 1904. No. 64452 G.

The Storage Battery. J. Lester Woodbridge. A lecture delivered at Stevens Inst. of Tech. Deals with the history, present practice in battery construction, capacity, operation, troubles, applications, &c. 4300 w. Stevens Ind—July, 1904. No. 64344 D.

Cantor Lectures.

Recent Advances in Electro-Chemistry. Bertram Blount. The Cantor lectures in London, giving a general review of copper refining and many other branches of electrochemistry. Diagrams. Serial. Part I. 7000 w. Jour Soc of Arts—Aug. 12, 1904. No. 64570 A.

Diaphragm.

A New Form of Diaphragm for Electrolytic Cells. F. Mollwo Perkin. Description, with illustration, of a diaphragm consisting of two cylinders of glazed ware, with five perforations, and asbestos, or other substance, filling the space between them. 700 w. Elec-Chem & Met—July, 1904. No. 64377 C.

Dissociation.

The Development of the Theory of Electrolytic Dissociation. Prof. Svante

We supply copies of these articles. See page 158.

Arrhenius. Address before the Royal Institution of Great Britain, with diagrams. 4000 w. Pop Sci Monthly—Sep., 1904. No. 64578 D.

Electro-Metallurgy.

Application of the Electric Furnace to the Metallurgy of Iron and Steel. P. McN. Bennie. Abstract of a recent paper, giving a classification of electric iron and steel processes and descriptive notes. 3000 w. Elec-Chem Ind—Aug., 1904. No. 64330 C.

Solubility of Gold in Certain Oxidizing Agents. V. Lenher. An account of an experimental investigation of the solubility of gold under the influence of nascent oxygen. 1800 w. Elec-Chem Ind—Aug., 1904. No. 64331 C.

See also Electrical Engineering, Transmission.

Ozone.

The Production and Utilization of Ozone. John B. C. Kershaw. Describes and illustrates ozonizers of recent date, and the experimental work carried out in connection with the production and utilization of ozonized air. 1500 w. Elec Rev, Lond—Aug. 19, 1904. Serial. 1st part. No. 64672 A.

ELECTRO-PHYSICS.

Alternating Currents.

A Physical Conception of Some Alternating-Current Phenomena. Lamar Lyndon. Discussion, with diagrams and curves, showing effects of inductance, resistance, etc. Serial. Part I. 2000 w. Elec Wld & Engr—Aug. 27, 1904. No. 64725.

Earth Currents.

Electric Tides and Earth Currents. W. H. Sharp. Gives results of researches made with a view to determining the origin and laws of earth currents. 1500 w. Elec Rev, Lond—Aug. 19, 1904. Serial. 1st part. No. 64671 A.

The Earth Currents. Abstract of a lecture by E. Guarini before the Société Belge d'Astronomie. 400 w. Elec Rev, N Y —Aug. 20, 1904. No. 64542.

Electrostatics.

Electrical Transmission Electrostatically Treated. J. Stanley Richmond. Aims to show that the science of electricity is really one of electrostatics, or of the rotative pressures of the electrical conditions of bodies of matter. 1500 w. Elec Rev, N Y —Aug. 6, 1904. No. 64273.

Rigidance.

Rigidance, a New Name for the Reciprocal of Capacity. James E. Ives. Discussion of mechanical analogies of electrostatic capacity, with formulæ and diagrams. Also editorial. 800 w. Elec Wld & Engr—Aug. 13, 1904. No. 64529.

Theory.

Reflections Suggested by the New Theory of Matter. Presidential address by the Right. Hon. A. J. Balfour to the British Assn. A lucid survey of the electrical theory of matter. 6000 w. Elect'n, Lond —Aug. 19, 1904. No. 64675 A.

GENERATING STATIONS.

Alternators.

Pressure Drop in Alternators. William Cramp. Discussion of the theory of alternator design, with diagrams. 3500 w. Elec Engr—Aug. 12, 1904. No. 64557 A.

Armature Reaction.

Armature Reaction in Alternators. James B. Henderson and John S. Nicholson. Account of a research to compare the theoretical and experimental armature reaction of a 30-kilowatt, three-phase alternator at the University of Glasgow. Diagrams. 2500 w. Elect'n, Lond—Aug. 5, 1904. No. 64545 A.

Brimsdown.

Power Supply to Tramways in North London. Illustrated description of station of the North Metropolitan Electrical Power Supply Co., furnishing current at 11,000 volts. Serial. Part I. 2000 w. Elect'n, Lond—Aug. 12, 1904. No. 64546 A.

Brussels.

The New Brussels Electric Power Station at Anderlecht. Frank C. Perkins. Illustrated description of a railway power station and its equipment. 1200 w. Engr, U S A—Aug. 15, 1904. No. 64676 C.

Commutation.

A Practical Test on Commutation. Arthur Keller. Discussion of commutation phenomena, and account of tests made by measuring the voltage drop between the brush and different commutator bars under it, with diagrams. Also editorial. 1500 w. Elec Wld & Engr—Aug. 20, 1904. No. 64534.

Dynamos.

High-Speed Direct-Current Dynamos for Railway Service (Schnellaufende Gleichstrom-Generatoren für Bahnbetrieb). H. Kikli-Kehlstadt. Illustrating a very substantial continuous-current machine designed by Rieter for direct-connection to hydraulic turbines making 500 revolutions per minute. 2000 w. Schweiz Bauzeitung —July 16, 1904. No. 64427 B.

Economics.

Economics in Supply Stations. A. J. Arnot. Read before the Elec. Assn. of Sydney. Discusses points of importance in the economical equipment and control of stations. 7500 w. Aust Min Stand—June 23 and 30, 1904. Serial. 2 parts. No. 64336 each B.

We supply copies of these articles. See page 158.

High School.

The Electric Plant of the Technical High School at Darmstadt (Die Elektrischen Einrichtungen im Neuen Kraftwerk der Technischen Hochschule Darmstadt). Prof. A. Sengel. An illustrated description of the isolated plant furnishing current for light, power and educational purposes at the Darmstadt Polytechnic. 3000 w. Zeitschr d Ver Deutscher Ing—July 16, 1904. No. 64400 D.

Hotel Plant.

See Mechanical Engineering, Power and Transmission.

Hydro-Electric.

The Hydro-Electric Station at Adelboden (Usine Hydro-Electrique d'Adelboden, Berne). P. Pflug. Describing a small Swiss station, using a Pelton wheel under 280 metres head, direct-connected to two Brown, Boveri dynamos. Two articles. 3000 w. Bull Tech de la Suisse Rom—June 25, July 10, 1904. No. 64478 each D.

Ipswich.

Ipswich Electric Lighting and Tramways Undertaking. Illustrated description of an English electric station and its equipment. 2000 w. Elec Rev, Lond—Aug. 5, 1904. No. 64550 A.

Leek.

Leek Electricity Works. Illustrated description of small English electric station, driven by town gas. 1600 w. Elec Rev, Lond—Aug. 12, 1904. No. 64553 A.

Loads.

Artificial Loads for the Dissipation of Electric Power. F. H. Davies. On the arrangement of a properly designed and permanent water load, considering points of importance. Ills. 2500 w. Elec Engr, Lond—July 22, 1904. No 64223 A.

London.

The London Underground Electric Railways Power Station. Illustrations and description of partially completed Chelsea station, in which will be installed ten 5500-kilowatt Westinghouse steam-turbine generators. 400 w. Tram & Ry Wld—Aug. 11, 1904. No. 64576 B.

Mining Plant.

See Mining and Metallurgy, Mining.

Railway Shops.

See Railway Engineering, Permanent Way.

St. Louis Fair.

The Largest Generating Unit at the World's Fair. Illustrated description of a 5000-horse-power Allis-Chalmers engine and Bullock three-phase generator, in operation in Machinery Hall. 2000 w. Elec Wld & Engr—Aug. 13, 1904. No. 64532.

Sheffield, Eng.

Two-Phase Turbo-Generator Station at Sheffield, England. Brief illustrated description of the change from the single to the two-phase system. 900 w. Elec Wld & Engr—July 30, 1904. No. 64233.

Stator Deflection.

Deflection of Stator of Direct-Current and Three-Phase Generators. F. Niethammer. Mathematical discussion of the mechanical deflection of dynamo yokes and frames, with diagram. 500 w. Elec Wld & Engr—Aug. 27, 1904. No. 64726.

Storage Battery.

A Unique Storage-Battery Installation. Henry Flay. Illustrated description of a large auxiliary and regulating storage-battery and booster plant at the lead mines of the St. Louis Smelting & Refining Co., St. Francois, Mo. 1500 w. Elec Wld & Engr—Aug. 20, 1904. No. 64535.

New Storage Battery Plant of the Northwestern Elevated Railroad, Chicago. Illustrated description of substation and method of operating battery. 1500 w. St. Ry Jour—Aug. 13, 1904. No. 64565 C.

The Proper Care of Storage Batteries (Soins à Donner aux Batteries d'Accumulateurs). E. Dieudonné. A discussion of the influence which proper care has upon the life and performance of electric storage batteries. Serial. Part I. 2500 w. Revue Technique—July 25, 1904. No. 64426 D.

See also Electrical Engineering, Electro Chemistry.

Tasmania.

Electric Lighting of Devonport, Tasmania. Illustrated description of a small electric station. 1200 w. Elec Engr—Aug 5, 1904. No. 64555 A.

Vouvry.

The Vouvry (Switzerland) Electric Power Plant. Illustrated description of a plant on the Rhone, driven by water supplied by the Tanay Lake. Single-phase current. 3000 w. Trac & Trans—Aug., 1904. No. 64348 E.

Wind Driving.

Wind-Driven Electrical Works. Dr. Alfred Gradenwitz. Brief illustrated description of a central station near Askov, Denmark, which has been worked with wind power for a year with satisfactory results. 900 w. Can Engr—Aug, 1904. No. 64339.

"Zone" Dynamos.

"Zone" Dynamos and Motors. Henry F. Joel. Illustrated description of dynamos and motors having a single field coil directly over the neutral zone of the armature. Serial. 2 parts. 1600 w. Elec Rev, Lond—Aug. 5 and 12, 1904. No. 64549 each A.

LIGHTING.

Incandescent Lamps.

The Conditions of Maximum Economy of Incandescent Lamps (Détermination des Conditions d'Economie Maxima pour le Fonctionnement des Lampes Electriques à Incandescence). Aymard Valéry. Deriving formulas including the first cost, life, and consumption of electric energy, for the determination of maximum economy. 1500 w. Revue Technique—July 25, 1904. No. 64425 D.

Lighting Plant.

Lighting Plant of a Large Office Building. Illustrated description of the generating equipment of the Whitehall Building, New York. 1400 w. Am Elect'n—Aug., 1904. No. 64173.

Nernst.

Improved Forms of the Nernst Lamp (Neue Ausführungsformen der Nernst lampe). Dr. Salomon. Illustrating a variety of mountings as well as the so-called "express" lamp, combining the Nernst and incandescent systems. 2000 w. Elektrotech Zeitschr—July 21, 1904. No. 64449 B.

See also Generating Stations.

MEASUREMENT.

Conductivity.

The Rapid Measurement of the Conductivity of Copper Electrolytes. Lawrence Addicks. An illustrated description of a method for quickly determining the conductivity of a solution which should be especially useful in electrolytic refining works. 1000 w. Elec-Chem Ind—Aug., 1904. No. 64329 C.

Fault Location.

Two Methods of Locating Faults in Telephone Cables. H. B. Stabler. Description with diagrams of methods used where paper insulation of lead-sheathed cables gets wet. 2000 w. Elec. Wld & Engr—Aug. 27, 1904. No. 64724.

Meters.

The Organization and Management of a Central Station Meter Department. A. J. Cridge. Outlines some of the methods adopted in the equipment, maintenance and working of a meter department in connection with an electricity supply undertaking. 3800 w. Elec Rev, Lond—July 29, 1904. No. 64312 A.

Motor Testing.

Method for Measuring the Output of Induction Motors. E. Alexanderson. Explains an interesting method of testing induction motors. It is essentially a method for determining torque and applies to power only when the speed is taken into account. 1300 w. Elec Wld & Engr—Aug. 6, 1904. No. 64335.

Reichsanstalt.

See Mechanical Engineering, Measurement.

Slip Meter.

A New Strobscopic Slip Meter (Ein Neuer Stroboskopischer Schlüpfungsmesser). Dr. G. Wagner. A description of the operation of apparatus using the principle of persistence of vision upon intermittent flashes of light for determining the slip of non-synchronous alternating and polyphase motors. 6000 w. Glasers Annalen—July 15, 1904. No. 64410 D.

Testing.

Notes on Testing. M. A. Sammett. Calls attention to the importance of temperature rise of apparatus under load in testing machines, and describes method giving accurate results. 1800 w. Elec Rev, N Y—Aug. 27, 1904. No. 64707.

Units.

Electrotechnical Systems of Units. Prof. David Robertson. A review of a paper by Fritz Emde before the Electrotechnischer Verein, on fundamental and derived units, with diagram. 1200 w. Elect'n, Lond—Aug. 12, 1904. No. 64548 A.

Wattmeters.

Calibration of Recording Wattmeters. George T. Hanchett. Considers methods used in testing meters, and gives information and suggestions. 2200 w. Am Elect'n—Aug., 1904. No. 64178.

MOTORS.

Direct-Current Motors.

Synopsis of Fundamentals Pertaining to Speed Variations in Direct-Current Motors and Details of a Motor Having a Wide Speed Range. Albert F. Hemingway. Relates briefly to the character and limitations, with illustrated description of a type of motor with wide range of speed variation. 2500 w. Am Elect'n—Aug., 1904. No. 64174.

Motor Efficiency.

The Calculation of Motor Efficiency in Railway Service (Die Berechnung der Motorleistung im Bahnbetriebe). Maximilian Müller. With graphical diagrams showing relations of load, speed, stops, etc., in determining the efficiency of railway motors. 3000 w. Zeitschr f Elektrotechnik—July 24, 1904. No. 64458 D.

Motor Testing.

See Electrical Engineering, Measurement.

Multiple Control.

Multiple Control of Press Motors in San Francisco. Wyatt H. Allen. Illustrated description of the system of electric driving of the Mutual Label & Lithograph Co., where a variety of motors are used, with

different requirements for speed variation. Illustrations and curves. 2400 w. Elec Wld & Engr—Aug. 27, 1904. No. 64723.

Single Phase.

On Single-Phase Commutating Motors. K. Michelmayer. Abstract translation from the *Elektrotechnische Zeitschrift.* A review of various types of motors, comparing them with the continuous-current motor. 4300 w. Elec Engr, Lond—July 29, 1904. No. 64310 A.

Single-Phase Series Motor. Ralph McNeill. Describes a construction free from interruption of current in any single armature circuit. 800 w. Elec Wld & Engr—Ang. 6, 1904. No. 64334.

Single-Phase Power Motors. R. B. Elder. Paper before the Pacific Coast Electric Transmission Assoc., discussing the single-phase alternating current motor principally from the commercial standpoint. 3000 w. Jour of Elec—Aug., 1904. No. 64559 C.

See also Street and Electric Railways.

TRANSMISSION.

Direct-Current.

The 70,000-Volt Continuous Current Transmission Experiments at Sécheron. A. Steens. Describes tests and claims superiority of direct over alternating-current. 2800 w. Eng Rec—Aug. 6, 1904. No. 64285.

Electrochemical Works.

Power Transmission for Electrochemical Works. Louis Bell. An analysis of the cost of developing water-powers for electrochemical plants. 2000 w. Elec-Chem Ind—Aug., 1904. No. 64327 C.

High-Voltage.

A Sixteen-Mile, 80,000-Volt Experimental Line. A. C. Balch. A paper before the Pacific Coast Electric Transmission Assoc., giving an illustrated account of experience in Southern California, particularly with insulators. 2500 w. Jour of Elec—Aug, 1904. No. 64558 C.

Mexico.

The Guanajuato, Mexico, Power Transmission. Robert McF. Doble. Illustrated detailed description of a fine power transmission plant. 3500 w. Elec Wld & Engr—Aug. 6, 1904. No. 64332.

Line Construction.

Medium-Span Line Construction. C. A. Copeland. Paper before the Pacific Coast Electric Transmission Association, giving an illustrated description of electric transmission lines in Southern California, with 225-ft. spans and wooden poles, and 300-ft. spans and steel poles. 2200 w. Eng News—Aug. 18, 1904. No. 64374.

Switching.

New Switching Station at Colorado City. Ilustrated detailed description. 1500 w. Elec Rev, N Y—July 30, 1904. No. 64168.

MISCELLANY.

Accidents.

Accidents from Electrical Machinery. Abstract from a report of the British Electrical Inspector of Factories, G. Scott Ram, on electric shock and mechanical accidents. 2400 w. Mech Engr—Aug. 13, 1904. No. 64681 A.

Bristol Fire.

Some Notes on the Bristol Electricity Works Fire. H. Faraday Proctor. Read before the Incor. Munic-Elec. Assn. A statement of the facts in regard to the fire which occurred Dec. 23, 1903, and the damage and the cause. Discussion. 4800 w. Elect'n, Lond—July 29, 1904. No. 64315 A.

Convention.

In Eighth Annual Convention Assembled. A complete unofficial report of the discussions held upon the papers read before the Monterey convention of the Pacific Coast Electric Transmission Assoc. 40,000 w. Jour of Elec—Aug., 1904. No. 64562 C.

Electrical Terms.

Voltage, Potential and Direction of Transmission. J. Stanley Richmond. Gives the writer's conception of these terms. 500 w. Elec Wld & Engr—July 30, 1904. No. 64234.

General Electric Co.

The Works of the General Electric Company. A general review of the Schenectady works, with plan and illustrations of tools, Curtis steam turbine, etc. Serial. 2 parts. 600 w. Engng—Aug. 5 and 12, 1904. No. 64511 each A.

Laboratory Appliances.

See Mining and Metallurgy, Gold and Silver.

Telpher Line.

See Street and Electric Railways.

South Africa.

Electric Engineering in South Africa. John Roberts. Principally an account of the municipal undertaking in Durban, Natal. 4500 w. Elect'n, Lond—July 29, 1904. No. 64314 A.

Standardisation.

The Standardisation of Electrical Machinery. An interim report of the British Engineering Standards Committee on generators, motors and transformers. 1500 w. Elect'n, Lond—Aug. 12, 1904. Also Engng—Aug. 12, 1904. No. 64518 A.

We supply copies of these articles. See page 158.

INDUSTRIAL ECONOMY

Contractors.

The Legal Obligations of a Contractor. Considers the rights and liabilities of those who enter upon the duty of carrying out large undertakings in England. 2000 w. Engr, Lond—Aug. 19, 1904. Serial. 1st part. No. 64662 A.

Cost-Keeping.

The Methodical Distribution of Shop Costs. H. H. Kress. Description of a cost-keeping system in operation in a large manufacturing plant, with many forms used. Serial. 1st part. 2500 w. Ir Age—Aug. 18, 1904. No. 64603.

Education.

Technical High Schools or Technical Universities (Technische Hochschulen oder Technische Fakultäten). O. Kammerer. A comparison between methods of technical education in Germany and America and the relation of the German technical high school to the university system. 5000 w. Zeitschr d Ver Deutscher Ing—Aug. 6, 1904. No. 64407 D.

Industrial Education in Germany. U. S. Deputy Consul Meyer. Abstract from Consular Reports, giving a general review of German industrial schools. Serial. 2 parts. 6000 w. Am Mach—Vol. 27. Nos. 33 and 34. No. 64598 C.

Estimates.

Engineers' Estimates of Cost. S. Whinery. Argument that the engineers' estimate should include only the engineering features of the work, and that he should not assume responsibility for other contingencies. Also editorial. 5000 w. Eng News—Aug. 11, 1904. No. 64362.

The Causes of Underestimates of Cost of Public Works. Editorial on engineers' estimating in general, with some reference to S. Whinery's article on Aug. 11. Eng News—Aug. 25, 1904. No. 64614.

Invention.

Address to the Engineering Section of the British Asociation. Hon. Charles A. Parsons. Remarks on the subject of invention and patents, including discoveries in physics, mechanics, chemistry and geology. 6000 w. Engng—Aug. 19, 1904. No. 64668 A.

Laboratory.

The Van't Hoff Laboratory at the University of Utrecht (Das Van't Hoff Laboratorium der Reichsuniversität zu Utrecht). Ernst Cohen. A general description, with plans, of the new chemical and physical laboratory, with an account of the opening ceremonies. 3500 w. Zeitschr f Elektrochemie—July 15, 1904. No. 64453 F.

Manual Training.

The Industrial Value of Manual Training. Frank T. Carlton. A discussion of the opportunities awaiting the pupil of the manual training school in the industrial operations of the United States. 2000 w. Engineering Magazine—September, 1904. No. 64482 B.

Tariff Commission.

Report of Mr. Chamberlain's Tariff Commission. A review of the first report of the Commission appointed to inquire into the probable effect of fiscal changes on the trade of the country. The present report deals with the heavy iron and steel trades. Also editorial. 7000 w. Ir & Coal Trds Rev—July 22, 1904. No. 64232 A.

Workmen's Dwellings.

The Structural Aspect of the Housing Problem. A. B. McDonald. Plans and descriptions of houses for the working classes in Glasgow. 1100 w. Public Works—Aug. 15, 1904. No. 64643 D.

MARINE AND NAVAL ENGINEERING

Anti-fouling Compounds.

Anti-fouling Compositions. From *Farben Zeitung*. Gives opinions from various authorities on submarine paints, and gives some new compositions. 2500 w. Sci Am Sup—Aug. 27, 1904. No. 64654.

Barges.

Barges Nos. 94 and 95, for the Standard Oil Company. Brief illustrated description of two of the largest bulk oil-carrying vessels ever built in the United States. 1100 w. Marine Engng—Aug, 1904. No. 64170 C.

Battleship.

The Great Battleship Ohio. Illustration and brief description and history of other

We supply copies of these articles. See page 158.

U. S. naval vessels bearing same name. 1200 w. Marine Rev—Aug. 18, 1904. No. 64712.

Boilers.

Report of the Committee on Naval Boilers. Full text of report of British Admiralty committee on water-tube boilers, with editorial comment. 7000 w. Engng—Aug. 5, 1904. No. 64515 A.

The Mumford Water-Tube Boiler. Illustrated description of a water-tube boiler designed to meet the requirements of torpedo-boats, launches, and similar vessels. 1000 w. Engng—Aug. 19, 1904. No. 64667 A.

Bulkhead Doors.

Pneumatic Hydraulic Device for Closing Bulkhead Doors (Pneumatisch-hydraulische Schottenschliessvorrichtung). Hermann Hildebrandt. Illustrating the system used on the steamers of the North German Lloyd lines for controlling the bulkhead doors from the bridge. 2000 w. Zeitschr d Ver Deutscher Ing—July 16, 1904. No. 64402 D.

Caronia.

The New Cunard Liner Caronia. Description of steamship recently launched on the Clyde, with gross tonnage of 21,000 and to have 21,000 horse power. Illustration and diagram showing comparative sizes of Cunard liners. 1500 w. Prac Engr—Aug. 12, 1904. No. 64678 A.

Draft.

The Draft of Vessels in Motion in Shallow Channels Compared with Their Stationary Draft. Henry N. Babcock. A record of observations upon the actual draft of large steamships when under way, as compared with their draft at their piers, with inferences. 2500 w. Eng News—Aug. 4, 1904. No. 64250.

Dry-Dock Plant.

See Mechanical Engineering, Internal-Combustion Motors.

Full-Rigged Ships.

The American Full-Rigged Ship. An illustrated article giving facts of interest in regard to a type of vessel rapidly disappearing. 2000 w. Naut Gaz—Aug. 4, 1904. No. 64266.

Japanese Navy.

The Japanese Navy. Rear-Admiral Sa-Sow. Paper read before Japanese Institution of Naval Architects, translated by Prof. Terano. A full description of warships built for Japan since 1897, with diagrams, tables and curves of bending moments, etc. 1500 w. Engng—Aug. 12, 1904. No. 64519 A.

Motor-Boat Race.

The British International Cup. Illustrated description of race in the Solent, near Isle of Wight, and of the motor boats which took part in it. 2200 w. Auto Jour—Aug. 6, 1904. No. 64716 A.

Calais-Dover Motor-Boat Race. Illustrated description of race and of boats which took part. 2000 w. Auto Jour—Aug. 13, 1904. No. 64717 A.

Motor Boat Reliability Trials. Illustrated descriptions of the entered boats. 3000 w. Auto Jour—July 30, 1904. No. 64291 A.

Motor Boating. Results of the Reliability Trials. Judges report and description of motor boat trials held in Southampton Water, England, with illustrations. 2000 w. Auto Jour—Aug. 13, 1904. No. 64718 A.

"Ontario."

Handsome New Coasting Steamship. Description, with illustration, of the "Ontario," built by the New York Shipbuilding Co. for the Merchants and Miners' Line, and brief history of this line. 1500 w. Naut Gaz—Aug. 11, 1904. No. 64699.

Schooners.

Development of the Schooner in American Waters. John H. Morrison. Reviews the history of this type of merchant vessel. Ills. 4000 w. Naut Gaz—Aug. 4, 1904. No. 64267.

Ship Telegraph.

Naval Telegraph Instruments. Reviews various means of communication, principally electrical, between the bridge, engine room and other parts of a ship. 1500 w. Elec Rev, Lond—Aug. 19, 1904. No. 64673 A.

Steamboat Test.

Boiler and Engine Test of a Small Steamboat. Warren Johnson. Paper before the Louisiana Engineering Society, giving data and results of short test of propeller boat having 17-horse-power engines, on the Mississippi. 800 w. Jour Assn of Engng Socs—July, 1904. No. 64582 C.

Steamships.

Twin-Screw Steamship Baltic, of the White Star Line, the Largest Ship Afloat. An illustrated detailed description of this large vessel and its equipment. 2800 w. Marine Engng—Aug., 1904. No. 64169 C.

Steamship Design.

Steamship Design. Carl C. Thomas. General account of the operations involved in designing vessels and their machinery, with cross section and construction data of a steamship. 3500 w. Cal Jour of Tech—May, 1904. No. 64636 C.

Torpedo Boat.

Torpedo Boat "No. 293" for the French

Navy. Illustrated description of boat fitted with Parsons steam turbines, 130 ft. long and of 26½ knots speed. 1000 w. Engng—Aug. 5, 1904. No. 64514 A.

Tug.

Ocean-Going Steam Tug Conestoga. Illustrated description of a new tug for the Philadelphia and Reading Railroad Company. 400 w. Marine Engng—Aug., 1904. No. 64172 C.

New Steel Tug Cornell. Description and illustration of a Hudson River towing steamer built by the Townsend-Downey Shipbuilding Co. 700 w. Naut Gaz—Aug. 18, 1904. No. 64711.

MECHANICAL ENGINEERING

AUTOMOBILES.

Carburetters.

See Mechanical Engineering, Internal-Combustion Motors.

Control.

A New Method of Control. Illustrated description of the Hopkins device for the regulation of the time of the exhaust valve of internal-combustion motors. 700 w. Autocar—Aug. 6, 1904. No. 64714 A.

Daimler.

The 28 H. P. Daimler Car. An illustrated detailed description. 1200 w. Autocar—July 30, 1904. Serial. 1st part. No. 64306 A.

Fire Engines.

Automobile Steam Fire Engines. M. Reichel. Illustrated description of steam-motor fire engines in Hanover, Germany, and their successful operation. 2000 w. Engr, Lond—Aug. 12, 1904. No. 64527 A.

Fuel.

Coal Tar and Spirits as Motor Fuels. Account of experiments made on the road with a Napier-Parsons parcels-delivery car, and comparison of coal-tar spirits with benzol for internal-combustion motors. 1000 w. Autocar—Aug. 6, 1904. No. 64713 A.

Gears.

Design for a Change Speed Gear for Motor-Driven Vehicles. J. E. Pfeffer. Working drawings and description of a design used on various types of touring cars, varying from 20 to 30 horse-power. 2400 w. Am Elect'n—Aug., 1904. No. 64177.

The Wilson and Pilcher Change-Speed Gear. Description and drawing of the latest design and practice. 1600 w. Autocar—July 23, 1904. No. 64220 A.

Krieger.

A Gasoline Electric Automobile. Emile Guarini. Illustrated detailed description of the Krieger 20 h.-p. gasoline-electric automobile, with particulars. 1400 w. Sci Am Sup—Aug. 27, 1904.—No. 64653.

Moderate Speed.

The Rational Car. Illustrates and describes a car of moderate speed, combined with simplicity and reliability. 900 w. Autocar—July 23, 1904. No. 64219 A.

Motor Van.

The Napier-Parsons Light Motor Van. Illustrates and describes a light delivery van of simple construction. 3300 w. Auto Jour—July 23, 1904. No. 64218 A.

Mountain Climbing.

Automobiles Climb Mount Washington. Angus Sinclair. An illustrated account of the feat undertaken July 11, 1904. Also some information in regard to the Mt. Washington railway. 1300 w. Loc Engng—Aug., 1904. No. 64210 C.

Petrol Car.

A 3-Cylinder "National" Petrol Car. Illustrated detailed description. 1500 w. Auto Jour—July 23, 1904. No. 64217 A.

Ravel Motor.

The Ravel "Intensive" Motor. Illustrated description of a new motor where an endeavor has been made to obtain a higher power within a definite bulk and weight. 1000 w. Motor Car Jour—Aug. 6, 1904. No. 64701 A.

Scotland.

Motor Vehicles in Scotland. More especially discussing the trade and manufacture of motor vehicles. 2200 w. U S Cons Repts—June, 1904. No. 64295 D.

Tires and Springs.

Tyres and Springs. J. S. V. Bickford. Illustrated discussion of tires and springs for automobiles. 1400 w. Autocar—Aug. 13, 1904. No. 64715 A.

White Car.

A Successful Steam Touring Car, and the Reasons of Its Success. Gives reasons why most steam cars are undesirable, and why the White Steam Car has retained its popularity. Ills. 1500 w. Auto Jour—Aug. 20, 1904. Serial. 1st part. No. 64658 A.

HEATING AND COOLING.

Electric Heating.

Electric Heating and the Field It Offers Central Stations. James I. Ayer.

We supply copies of these articles. See page 158.

Reviews the conditions that have affected the development of electric heating, and discusses how to popularize and successfully introduce this method. 5500 w. Cent Sta—Aug., 1904. No. 64342.

Ice Making.

An Efficient Ice Plant at East Hampton, N. Y. Illustrates and describes a 10-ton ice-making plant of the plate class that produced on a seven-day test, an average of 14.04 tons of ice per ton of coal, at the rate of 14.6 tons daily. 1800 w. Eng Rec—Aug. 6, 1904. No. 64277.

Ice Making and Refrigeration at Louisiana Purchase Exposition. Description and views of the 500-ton plant installed. 3000 w. Ice & Refrig—Aug., 1904. No. 64247 C.

Refrigeration.

Artificial Refrigeration. F. E. Matthews. An explanation of systems used, with illustrations. 2500 w. Power—Aug., 1904. No. 64195 C.

Refrigeration Standard.

Standard Unit Ton of Refrigeration. Description and views of plant and apparatus used for special tests made to determine the actual work accomplished by the refrigerating machine under conditions such as ordinarily prevail. 2700 w. Ice & Refrig—Aug., 1904. No. 64246 C.

HYDRAULICS.

Air Lift.

The Air Lift. Illustrated description of method of raising water by compressed air. 1500 w. Engr, U S A—Aug. 15, 1904. No. 64677 C.

Efficiency Trials of Air-Lift Pumping Plant. J. W. M. Richardson. Abstract of a paper read before the British Assn. of W.-Wks. Engrs. An illustrated description of the plant of the Birkenhead Corporation. 3000 w. Mech Engr—Aug. 20, 1904. No. 64659 A.

Centrifugal Pumps.

Tests of De Laval Centrifugal Pumps. Account of tests made by Prof. J. E. Denton and Prof. William Kent, at the works of the De Laval Steam Turbine Co., Trenton, N. J. 1800 w. Eng Rec—Aug. 20, 1904. No. 64502.

The De Laval Tigh-Pressure Centrifugal Pumps (Pompes Centrifuges de Laval à Haute Pression). K. Sosnowski. A fully illustrated report upon the combination system of centrifugal pumps arranged for direct connection with the de Laval steam turbine. 7000 w. Bull Soc d'Encour—June, 1904. No. 64163 G.

The Rateau Multicelular Centrifugal Pump for High Heads (Les Pompes Centrifuges Multicellulaires à Grande Elévation du Système Rateau). M. Rey. A fully illustrated account of the Rateau system, using a number of pumps in series, operated by electric motors, steam turbine, or hydraulic turbine. 8000 w. Bull Soc d'Encour—June, 1904. No. 64464 G.

Flow.

See Civil Engineering, Waterways and Harbors.

Impulse Wheel.

Efficiency Tests of an Impulse Wheel. Prof. Joseph N. LeConte. Preliminary article on methods employed and results obtained in tests of a 3-foot Pelton wheel at the Univ. of California. Illustrations and tables. 1500 w. Cal Jour of Tech—May, 1904. No. 64634 C.

Laboratory.

The Hydraulic Laboratory of the Technical High School at Darmstadt. (Das maschinenbau laboratorium III des Technischen Hochschule Darmstadt. Prof. A. Pfarr. Illustrating and describing the testing flume, weirs, pumping plant and hydraulic laboratory equipment at the Darmstadt Polytechnic. 2000 w. 1 plate. Zeitschr d Ver Deutscher Ing—July 16, 1904. No. 64401 D.

Pulsometer.

The Pulsometer Steam Pump on Public Works. P. E. Hodgkin. Illustrated descriptions of this pump raising water in foundation and sewage work, baths, locomotive tanks and other purposes. 2500 w. Public Works—Aug. 15, 1904. No. 64648 D.

Rand Water.

See Mining and Metallurgy, Mining.

Turbines.

High-Pressure Water Wheels, with Particular Reference to the Girard and Francis Turbines. E. G. De Wald. Paper before the Pacinc Coast Electric Transmission Assoc., giving a description of these turbines, with illustrations and diagrams. 2000 w. Jour of Elec—Aug., 1904. No. 64560 C.

Valves.

The Action of Spring-Loaded Pump-Valves (Die Wirkungsweise Federbelasteter Pumpenventile und ihre Berechnung). H. Berg. An exhaustive mathematical study of the action of pump valves, including the results of investigation with the indicator. Three articles. 12000 w. Zeitschr d Ver Deutscher Ing—July 23 30, Aug. 6, 1904. No. 64403 each D.

INTERNAL-COMBUSTION MOTORS.

Carburetters.

Carburetters. J. S. V. Bickford. An examination into the construction and function of the spray type of carburetter from the theoretical side. Ills. 2500 w. Engr, Lond—July 22, 1904. No. 64231 A.

Dry-Dock Plant.

Gas Power Plant at Elderslie Graving

Dock. Illustrated description of Crossley gas producer plant and gas engines, for operating pumps at Shearer's shipyard on the Clyde. 1000 w. Engr, Lond—Aug. 12, 1904. No. 64524 A.

Gas Power.

Power Installation at the Isle of Elba for the Utilization of Blast Furnace Gas. Emile Guarini. Illustrated description of an interesting example of the utilization of blast furnace gas for the production of power by means of gas engines and dynamos. 800 w. Power—Aug., 1904. No. 64193 C.

Gas Washer.

The Theisen Centrifugal Gas Washer. Illustrated description of apparatus for purifying gas from blast furnaces, etc., for use in gas engines. 700 w. Ir Age—Aug. 18, 1904. No. 64601.

Heysham Harbor.

See Civil Engineering, Waterways.

High-Speed.

High-Speed Internal-Combustion Engines. Illustrated descriptions of various light, gasoline engines, and of methods of ignition. Serial. Part 1. 3000 w. Engr, Lond—Aug. 12, 1904. No. 64523 A.

Oil Engines.

Oil Engines. H. B. Maxwell. Illustrates and describes some of the main types of the various oil engines. 1600 w. Marine Engng—Aug., 1904. No. 64171 C.

Ravel Motor.

See Mechanical Engng., Automobiles.

Waste Heat.

An Enquiry Into the Waste Heat from Gas Engines, with Some Suggestions for its Useful Application. George Chasser. Read before the Inst. of Heat & Ven. Engrs. at Liverpool. An investigation of heat losses, giving diagrams showing suggested arrangements of the apparatus. 4500 w. Plumb & Dec—Aug. 1, 1904. No. 64702 A.

MACHINE WORKS AND FOUNDRIES.

Bridge Works.

Clarke-Street Works, Derby. Illustrated description of these new works, which are an extension of the large plant of A. Handyside & Co., Ltd. 2200 w. Engr, Lond—July 29, 1904. No. 64323 A.

The American Bridge Company's Ambridge Works. Illustrated detailed description of the largest bridge plant in the world. 2500 w. Ir Age—Aug. 4, 1904. No. 64239.

Castings.

A Heavy Casting. Illustrates and describes a heavy casting made in Seattle, Wash., with the mold and method employed in pouring the same. 800 w. Foundry—Aug., 1904. No. 64261.

Chemistry.

Applied Chemistry in Foundry Work (Angewandte Chemie im Giessereibetriebe). Oskar Leyde. A discussion of the value of chemical analysis of foundry irons, and the economy to be effected by the general application of chemistry to the regular work of the foundry. Serial. Part I. 3500 w. Stahl u Eisen—July 15, 1904. No. 64428 D.

Cost-Keeping.

See Industrial Economy.

Dies.

Notes on Die Making. Frank E. Shailor. Illustrates a die containing several novel features, and describes the construction. 1600 w. Mach, N. Y.—Aug., 1904. No. 64198 C.

Electric Driving.

The Electric Equipment of Workshops and Factory Buildings. Percival Robert Moses. A discussion of the advantages of electric driving, with suggestions as to the choice of apparatus for various kinds of work. 3000 w. Engineering Magazine—September, 1904. No. 64485 B.

Emery Wheels.

The Mounting of Emery Wheels. Reproduction of remarks by Mr. Verney on the bursting of emery wheels and means of prevention, with figures. 1000 w. Mech Engr—Aug. 6, 1904. No. 64679 A.

Iron Works.

Mechanical Appliances in Iron Works Operation (Maschinelle Einrichtungen im Eisenhüttenwesen). Fr. Frölich. Discussing especially the various auxiliary machinery used in connection with the manufacture of iron and steel. The present instalment describes traveling ladles for hauling slag and molten metal. Serial, Part I. 3500 w. Zeitschr d Ves Deutscher Ing—Aug. 6, 1904. No. 64406 D.

The Lookout Mountain Iron Company. Description of the company's property and plant at Battelle, Ala. 3500 w. Ir Age—Aug. 4, 1904. No. 64241.

Jigs.

Flat Turret-Lathe Jigs. Descriptions and illustrations of jigs and fixtures used in the manufacture of the Jones & Lamson lathe. 1500 w. Am Mach—Vol. 27, No. 34. No. 64594.

Lathes.

Some Lathe Attachments for the Amateur Machine Shop. Robert G. Griswold. Illustrates and describes angle plates, facing attachment and grinding attachment, explaining methods of using. 2000 w. Am Mach—Vol. 27, No. 31. No. 64243.

The Le Blond Quick-Change Feed Lathe. Illustrated description of lathe equipped with quick-change gear box for feeding and thread cutting. 1200 w. Ir Age—Aug. 25, 1904. No. 64604.

We supply copies of these articles. See page 158.

Model Plant.

Model Plant of the New Britain Machine Company. Illustrates and describes a model example of the mill, type of construction applied to machine shop use. 3300 w. Mach, N. Y.—Aug., 1903. No. 64197 C.

Planers.

A Test of a Motor Driven Planer. J. C. Stern. An account of an interesting test, with diagrams. 800 w. Am Engr & R R Jour—Aug., 1904. No. 64201 C.

Electrically Driven Planer with Speed-Changing Countershaft. Illustrated description of Pond planer with Crocker-Wheeler motor. 1000 w. Am Mach—Vol. 27, No. 34. No. 64597.

Portable Tools.

Electrically-Driven Portable Tools. Dr. Alfred Gradenwitz. Illustrates and describes electrically-driven portable drills, and their applications. 1200 w. Mach, N. Y.—Aug., 1904. No. 64199 C.

Shops.

See Railway Engineering, Permanent Way; and Street and Electric Railways.

Shop Methods.

Some Gaging and Measuring Methods at the Works of the Westinghouse Machine Company. Illustrates instruments and describes the method of using them. 1800 w. Am Mach—Vol. 27, No. 31. No. 64242.

Spacing Attachment.

An Odd Spacing Attachment for the Milling Machine. A. Cashman. Illustrated description. 1000 w. Am. Mach—Vol. 27, No, 34. No. 64595.

Steel Plant.

Steel Plant of the Grand Crossing Tack Company. Illustrated detailed description of plant for the manufacture of wire rods, wire nails, and other wire products. 2400 w. Ir Age—Aug. 4, 1904. No. 64240.

Tools.

The Introduction of High-Speed Steel into a Factory. A. D. Wilt, Jr. Practical notes upon the difficulties encountered in the use of the new steels; including character of tools, methods of using, instruction of workmen, etc. 3000 w. Engineering Magazine—September, 1904. No. 64480 B.

MATERIALS OF CONSTRUCTION.

Alloys.

Stable and Unstable Equilibrium in Iron-Carbon Alloys (Labile und Metastabile Gleichgewicht in Eisen-Kohlenstoff Legierungen). E. Heyn. A study of the changes which occur among the iron-carbon alloys, illustrated with microphotographs. 5000 w. 1 plate. Zeitschr f Elektrochemie—July 22, 1904. No. 64455 F.

The Chemistry of Alloys for Naval Use. Translated from the *Revue de Chimie Industrielle*. Reviews various alloys used and the uses for which they are suitable. 1200 w. Stevens Ind—July, 1904. No. 64345 D.

Elasticity.

Researches in the Theory of Electricity (Weitere Untersuchungen über die Theorie der Elastizitat). F. Rust. A mathematical study of the elastic resistance of beams to transverse loads. 4000 w. Oesterr Wochenschr f d Oeff Baudienst—June 11, 1904. No. 64467 D.

Emery Wheels.

Experimental Work with Solid Emery Wheels. T. Dunkin Paret. Reports investigations and tests of emery wheels and the results. 6500 w. Jour Fr Inst—Aug., 1904. No. 64357 D.

Pipe Covering.

Testing Pipe Covering. George T. Hanchett. A brief description of a simple electrical method of testing. 1000 w. Cent Sta—Aug., 1904. No. 64341.

Shafts.

Is a Hollow Shaft as Strong and Durable as a Solid Shaft of the Same Diameter? If so, what is the Method of Manufacture and Proportion of Bore to Size of Shaft. Illustrated paper by Robert McF. Doble on the forging and treatment of steel, and discussion and letters by others. 10000 w. Pro Pacific Coast Ry Club—July 16, 1904. No. 64633 C.

Steel.

Special Steels for Automobile Construction (Spezialstähle für den Kaftkagenbau). Illustrating special shapes of steel of extreme strength and toughness especially intended for automobile construction. 2500 w. Stahl u Eisen—July 15, 1904. No. 64431 D.

Wire Rope.

Notes on the Theory of Wire Rope (Beiträge zur Theorie der Drahtseile). Dr. Hans Benndorf. A mathematical investigation of the relation of the resistance of a wire rope to that of the wires of which it is composed. Two articles. 7500 w. Zeitschr d Oesterr Ing u Arch Ver—July 22, 29, 1904. No. 64415 each D.

MEASUREMENT.

Decimal System.

Scheme for Decimalizing English Weights and Measures. Résumé of a pamphlet by Thomas A. Barber. 2000 w. Bul Int Ry Cong—July, 1904. No. 64320 E.

Impact Tests.

Tensile Impact Tests of Metals. W. Kendrick Hatt. Abstract of paper before the American Society for Testing Materials, with illustrations and tables, de-

We supply copies of these articles. See page 158.

scribing experiments made at Purdue University. 1400 w. R. R. Gaz—Vol. XXXVII, No. 11. No. 64627.

The Wanner Optical Pyrometer (Das Optische Pyrometer von Wanner). A general description of the instrument and its use, showing a high degree of accuracy in measuring temperatures above 900 degrees by the light emitted. 2500 w. Oesterr Zeitschr f Berg u Hüttenwesen—Aug. 6, 1904. No. 64439 D.

Pyrometers.

Pyrometers Suitable for Metallurgical Works. Abstract of a report prepared by a committee appointed by the Iron & Steel Inst. Ills. 4000 w. Elect'n, Lond—July 22, 1904. No. 64227 A.

Reichsanstalt.

The Work of the Reischsanstalt in 1903. Abstract of Director Kohlrausch's report on the testing and research work of the Physikalisch-Technische Reischsanstalt near Berlin. 4000 w. Engng—Aug. 5, 1904. No. 64512 A.

Rotating Disc.

The Stresses in a Rotating Disc (Die Spannungen in Einer Rotierenden Scheibe). C. Reimann. A mathematical investigation of the stresses set up in various parts of a flat disc when rotated at high velocities. 2000 w. Glasers Annalen—Aug. 1, 1904. No. 64412D.

Slide Rule.

Calculating Cone Steps and Back-Gearing Ratios by the Slide Rule. Robert A. Bruce. Description and diagrams showing use of slide rule in machine-tool design. 1,500 w. Am Mach—Vol. 27, No. 33. No. 64592.

Stator Deflection.

See Electrical Engineering, Generating Stations.

Testing Bureau.

The Royal Testing Laboratory at the Berlin Technical High School (Das Königliche Materialprüfungsamt der Technischen Hochschule Berlin). An editorial review of the new quarters of the Government testing bureau, with especial reference to its work upon iron and steel. 3500 w. Stahl u Eisen—July 15, 1904. No. 64429 D.

Testing Machine.

300-Ton Universal Testing Machine. Translation of article by M. Breuil in *Le Génie Civil*, giving a well illustrated account of a large testing machine built by Messrs. Joshua Buckton & Co., for Conservatoire des Arts et Métiers, Paris. 2200 w. Engng—Aug. 12, 1904. No. 64516 A.

POWER AND TRANSMISSION.

Cable Traction.

The Operation of Cars and Transfer Tables by Continuous Running Cables (Die Bewegung von Eisenbahnwagen und Schiebebühnen mittels stetig Umlaufenden Endlosen Seils). H. Glinz. Illustrating the use of an endless continuous running cable for hauling and transferring cars about a yard, using grip connections. Serial. Part I. 3500 w. Glückauf—Aug. 6, 1904. No. 64437 B.

Compressed Air.

Compressed Air in Quarrying. Claims economies obtained by substituting air for steam power. Ills. 1800 w. Mines and Min—Aug., 1904. No. 64300 C.

Power Transmission by Compressed Air. Lucius I. Wightman. Illustrates and describes a system at a North Amherst, Ohio, quarry, where the power is used by the same machines which originally were run by steam. 5000 w. Power—Aug., 1904. No. 64191 C.

Conveyor.

Electrically Operated Temperley Transporters. Illustrated description of coal handling apparatus for electric stations. 1200 w. Elect'n, Lond—Aug. 5, 1904. No. 64543 A.

The Kreiss Oscillating Conveyor (Die Kreiss Schwinge Förder Rinne). Prof. M. Buhle. Illustrating and describing a form of trough conveyor mounted on springs, and given an oscillating movement which cause the material to travel continuously in one direction. 1600 w. Glückauf—July 16, 1904. No. 64433 B.

Elevator Accidents.

Some Recent Elevator Accidents. Edward Van Winkle. Discussion with illustrations of elevator accidents in New York and the necessity for more careful inspection. 1500 w. Eng News—Aug. 25, 1904. No. 64609.

Gears and Springs.

Topical Discussion on Forms and Relative Advantages of Teeth in Gears. On cycloidal and involute teeth, and also on helical and elliptical springs. 4000 w. Pro Engrs' Soc of W. Pa—May, 1904. No. 64632 D.

Hotel Plant.

Mechanical Plant of the Hotel Lafayette, Buffalo. Description, with plan, of steam, electric, compressed air, refrigerating, heating, pumping and elevator plant. 1500 w. Eng Rec—Aug. 20, 1904. No. 64509.

Pneumatic Tools.

Compressed Air and Pneumatic Tools in Engineering Works. Frank Fielden. On the advantages and uses of compressed air in the shop. 2500 w. Engng—Aug. 19, 1904. No. 64666 A.

Power Plant.

The Power Plant of the Littleton

Creamery, Denver. Howard S. Knowlton. Describes an interesting plant for an establishment for the manufacture of butter, and the cold storage of butter, eggs, milk, cream and cheese. 2000 w. Eng Rec—Aug. 6, 1904. No. 64279.

Railway Shops.

See Railway Engineering, Permanent Way.

STEAM ENGINEERING.

Boilers.

Care and Management of Steam Boilers. William H. Fowler. The present number considers safety valves. Ills. 1500 w. Mech Engr—July 30, 1904. Serial. 1st part. No. 64307 A.

Mechanical Draught for Boilers. Walter Yates. Read at Liverpool, before the Inst. of Heat & Ven. Engrs., Considers the combustion of fuel, natural draught, and several forms of mechanical draughts. Ills. 4500 w. Elec Engr, Lond—July 29, 1904. No. 64311 A.

See also Marine and Naval Engineering.

Boiler Economies.

Boiler House Economies. Reginald S. Downe. Abstract of paper and discussion before the Incorporated Municipal Electrical Ass'n, reviewing the whole subject of efficient steam generation. Diagrams and tables. 7000 w. Elect'n, Lond—Aug. 5, 1904. No. 64544 A.

Engines.

The Murray Rolling Mill Engine. Illustrated detailed description of an exhibit at the St. Louis World's Fair. 1700 w. Ir Age—Aug. 11, 1904. No. 64350.

Feed-Water.

Greasy Condensation Water as Boiler Feed. William Paterson. Read before the Junior Inst. of Engrs. Discusses the consequences which result from the use of such water. Ills. 4000 w. Mech Engr—July 23, 1904. No. 64221 A.

The Deposit of Salts in Steam Boilers (Salzausscheidungen in Dampf Kesseln). Dr. Steger. Giving analysis of various waters, showing the extent to which the dissolved salts are decomposed in the steam boiler. 1200 w. Gesundheits-Ingenieur—July 20, 1904. No. 64419 B.

Fuel.

Smokeless and Economical Burning of Fuel. Charles Barter. Read before the Inst. of Heat & Ven. Eng. at Liverpool. A general survey of the subjects. 3000 w. Plumb & Dec—Aug. 1, 1904. No. 64703 A.

Hotel Plant.

See Mechanical Engineering, Power and Transmission.

Indicator Diagrams.

Diagrams from a Double Tandem Hoisting Engine (Diagramme einer Zwillings-Tandem Fördermaschine). Otto Himmelheber. A comparison of theoretical indicator diagrams with those obtained under actual working conditions. 1000 w. Zeitschr d Ver Deutscher Ing—July 23, 1904. No. 64405 D.

The Working Out of Indicator Diagrams. H. E. Hodgson. The present number discusses methods of finding the mean effective pressure. 1700 w. Elec Engr, Lond—July 22, 1904. Serial. 1st part. No. 64224 A.

Mechanical Draught.

Mechanical Draught for Boilers. Walter Yates. Paper before the Institution of Heating and Ventilating Engineers (British), giving descriptions and illustrations of mechanical draught apparatus. 3000 w. Mech Engr—Aug. 13, 1904. No. 64680 A.

Oil Fuel.

Boiler Trials with Oil Fuel at Los Angeles. A report of the acts of oil-burning water-tube boilers of the Babcock & Wilcox Co., and the Stirling Co. Ills. 2800 w. Eng Rec—Aug. 6, 1904. Serial. 1st part. No. 64287.

Oil Troubles.

Oil Dripping and Oil Slinging. Hereford Berry. An illustrated article discussing the causes and cures for these troubles. 1800 w. Am Mach—Vol. 27, No. 32. No. 64352.

Piping.

Pipe Connections (Ueber Rohrleitungen). A general discussion of steam piping and pipe connections together with plans of mains for batteries of steam boilers, according to the recommendations of the Dortmund boiler inspection association. 4500 w. Glückauf—July 30, 1904. No. 64436 B.

Piston Rods.

Piston Rods of High-Speed Engines. Ernest R. Briggs. Discussion of the use of Prof. Barr's formulæ in engine design, and particularly describing design of piston rods, with diagrams. 800 w. Am Mach—Vol. 27, No. 33. No. 64593.

Pumping Engine.

Pumping Engine for a Floating Dock. Illustrated description of the engines, and pumps for the Kobe floating dock, Japan. 900 w. Engr, Lond—July 22, 1904. No. 64230 A.

Steam Plant.

Design and Test of a Modern Steam Power Plant. Edward G. Hiller. Particulars of the construction and test of a modern factory steam plant, designed with the object of obtaining good commercial economical results. 9000 w. Ills. Inst of Mech Engrs—July 22, 1904. No. 64166 D.

We supply copies of these articles. See page 158.

Steam Turbines.

Steam-Turbine Construction. O. Lasche. A detailed account of experiments carried out by the Allgemeine Elektricitäts Gesellschaft, with illustrated description of various designs. 3000 w. Engng—Aug. 19, 1904. Serial. 1st part. No. 64665 A.

Superheating.

Recent Investigations upon the Specific Heat of Superheated Steam (Neuere Versuche über die Spezifische Wärme des Ueberhitzten Wasserdampfes). H. Lorenz. A comparison of the results of Carpenter and Jones with those of the author. 1000 w. Zeitschr d Ver Deutscher Ing—Aug. 6, 1904. No. 64408 D.

Superheated Steam for Locomotives in Germany. A report on the experiments in Germany with superheaters for locomotives, the types, and the conclusions. 4000 w. Ry & Engng Rev—Aug. 6, 1904. No. 64326.

Superheaters. Benjamin Taylor. Illustrates and describes some new types invented by W. H. Watkinson, giving results of practical tests. 3500 w. Power—Aug., 1904. No. 64192 C.

The Generation of Superheated Steam. Otto Berner. From the German as published in *Zeitschrift des Vereines Deutscher Ingenieure.* Facts deduced from experiments with superheated steam, considering the material required in the construction of steam superheaters, the transmission of heat, the velocity of steam through the pipes, and the work done by the boilers. 3500 w. Power—Aug., 1904. No. 64194 C.

The Principles and Practice of Superheating. W. H. Booth. General discussion of superheated steam and its use. 3000 w. Tram & Ry W'ld—Aug. 11, 1904. No. 64577 B.

Testing.

Design and Test of a Modern Steam Power Plant. Edward G. Hiller. Abstract of paper before the Institution of Mech. Engrs., giving an illustrated descriptive test of boilers and engines at the mills of Bessbrook Spinning Co., County Armagh, Ireland. 3500 w. Mech Engr—Aug. 6, 1904. Also Prac Engr—Aug. 5, 12 and 19, 1904. No. 64682 each A.

To Test for Blows in Valves, Cylinder Packing, Separate Exhaust Valve and Intercepting Valve. S. H. Draper. Suggestions for testing with discussion of causes of some engine troubles. 1500 w. Loc Engng—Aug., 1904. No. 64207 C.

Turbo-Generator.

See Electrical Engineering, Generating Stations.

Water Gauges.

Boiler Water Level Indicators. R. T. Strohm. Discusses gauge glasses, and try-cocks, also devices for closing communication with the boiler, etc. Ills. 2500 w. Am Elect'n—Aug., 1904. No. 64176.

MISCELLANY.

Aeronautics.

Sustaining Screw Propellers (Sur les Helices Sustentatrices). Edgar Taffoureau. An examination of the computations of Col. Renard, showing that the power required to sustain a weight has been underestimated. 1500 w. Comptes Rendus—Aug. 1, 1904. No. 64443 D.

The Dynamics of the Aeroplane (Notes sur la Dynamique de l'Aeroplane). M. Vallier. A mathematical study of the relations between the mechanics of the problem with the experimental laws of physics, taking into account the various speeds and powers of motors. 15000 w. Revue de Mécanique—July, 1904. No. 64460 E + F.

The Longitudinal Stability of Dirigeable Balloons (Ballons Dirigeables, Stabilite Longitudinale). Ch. Renard. A communication to the French Academy, discussing the use of auxiliary inflated cylinders attached to a cylindro-conical balloon to increase its stability. 1800 w. Comptes Rendus—July 18, 1904. No. 64441 D.

The Aeroplane. M. Rudolphe Soreau. Translated from *La Vie Automobile.* Extract from a lecture given before the French Soc. of Civ. Engrs., showing some of the difficulties met with in the construction of an aeroplane flying machine. 2200 w. Sci Am Sup—Aug. 27, 1904. No. 64651.

Galvanizing.

The Porter Galvanizing Process. Illustrated description of apparatus for removing the excess metal from galvanized articles. 1200 w. Ir Age—Aug. 18, 1904. No. 64600.

Invention.

See Industrial Economy.

Lock.

Development of the Star-Point Permutation Lock. Illustrated description of a new combination lock which is noiseless, can be worked in the dark, and is cheap to manufacture; the invention of Oberlin Smith. 4500 w. Am Mach—Vol. 27, No. 34. No. 64596.

Steam Shovels.

A Railway Steam Shovel of New Design. Illustrates and describes a new shovel designed by A. W. Robinson, noting the important changes. 2800 w. Eng News—Aug. 4, 1904. No. 64253.

We supply copies of these articles. See page 158.

MINING AND METALLURGY

COAL AND COKE.

Analysis.

Sampling, Analyses and Preparation of Coal. F. R. Wadleigh. Many practical points on the analysis and testing of coal, with tables of proximate and ultimate analyses. 3000 w. R. R. Gaz—Vol. XXXVII, Nos. 11. No. 64626.

Belgium.

The Coal Basin of Northern Belgium (Le Bassin Houiller du Nord de la Belgique). Paul Habets. A commercial and geological account of the district with map and sections. 12000 w. 3 plates. Mem Soc Ing. Civ de France—May, 1904. No. 64444 G.

Briquetting.

The Briquetting Plant at Stockton, California. Robert Schorr. Description of a large plant for crushing lignite and making it into briquettes. 1000 w. Eng and Min Jour—Aug. 18, 1904.—No. 64393.

Coke Plant.

Segundo Coke Plant. R. M. Hosea. An illustrated description of the ovens and coal washing plant of the Colorado Fuel & Iron Co. 5000 w. Mines and Min—Aug., 1904. No. 64298 C.

Duluth.

The Zenith Furnace at Duluth. Dwight E. Woodbridge. Description, with illustrations, of a coke-oven gas plant, blast furnace, and coal dock of the most modern kind. 1500 w. Eng & Min Jour—Aug. 11, 1904. No. 64389.

Blast Furnace and By-Product Coke Plant of the Zenith Furnace Co. Illustrated description of a remodeled plant at Duluth, Minn. 2500 w. Ir Trd Rev—Aug. 11, 1904. No. 64354.

Ehrenfeld, Pa.

The Ehrenfeld Colliery. Description, with illustrations, of the electric plant and other features of coal mines near Johnstown, Pa. 2000 w. Eng & Min Jour—Aug. 18, 1904. No. 64391.

Handling Plant.

Coal Handling Plant at the Douglas Bank Colliery, Wigan. Illustrated description of coal picking, screening and loading plant. 1000 w. Ir & Coal Trds Rev—Aug. 12, 1904. No. 64693 A.

Mine Surveying.

See Civil Engineering, Measurement.

Spontaneous Combustion.

The Spontaneous Ignition of Coal. Alfred O. Doane. Discussion of the causes of, and remedies for, spontaneous ignition of coal. 1400 w. Eng News—Aug. 18, 1904. No. 64372.

COPPER.

Arizona.

The Mines of Prescott, Arizona. A general review of the mining industry of this district, including the United Verde and other copper, gold and silver mines. Illustrations. 2000 w. Eng & Min Jour—Aug. 11, 1904. No. 64385.

Notes on the Bisbee District, Arizona. Dwight E. Woodbridge. Account of copper mines and companies. 2000 w. Eng & Min Jour—Ang. 25, 1904. No. 64616.

The Mines of Clifton District, Graham Co., Arizona. General description of copper mines, with illustrations of smelting plants. 1000 w. Min & Sci Pr—Aug. 13, 1904. No. 64691.

California.

The Copper Mines of Shasta County, Cal. Dwight E. Woodbridge. An interesting account of mines which have yielded nearly $30,000,000 worth of copper, and over half the silver mined in California. 2800 w. Ir Age—Aug. 11, 1904. No. 64351.

Deposits.

The Present Condition of Copper-Mining in the South. Walter Harvey Weed. Ducktown (Tenn.) is at present the only producer of any magnitude in the south, but promising reports of many other districts are given. 2300 w. Mfrs Rec—Aug. 11, 1904. No. 64353.

Greene Consolidated.

The Greene Consolidated Copper Company. Dwight E. Woodbridge. Illustrated description of the copper mines aud reduction works of Cananea, Sonora, Mexico. 3000 w. Ir Age—Aug. 25, 1904. No. 64605.

Mansfeld.

Copper Smelting at Mansfeld. Translation of an article in *Metallurgie*, giving an account of metallurgical operations at this great German copper mine. 1500 w. Eng & Min Jour—Aug. 11,1904. No. 64388.

Metallurgy.

Notes on the Metallurgy of Copper, Lead and Zinc. Walter Renton Ingalls. A review of American metallurgical practice. 4200 w. Min Mag—July, 1904. No. 64185 C.

Refining.

The Pioneer Electrolytic Copper Refinery of the United States. An illustrated description of the works of the Balbach

We supply copies of these articles. See page 158.

Smelting and Refinery Co., in Newark, N. J. 2000 w. Elec-Chem Ind—Aug., 1904. No. 64328 C.

GOLD AND SILVER.

Amalgamation.

Pan Amalgamation at the "Minas del Tajo," Rosario, Mexico. A. E. Drucker. Description of ore treatment at these silver and gold mines, particularly with reference to the saving of mercury, with figures of forms of shoes for the settlers. 3000 w. Cal Jour of Tech—May, 1904. No. 64639 C.

Assaying.

Cramer's Assaying. L. S. Austin. A review of an old work on assaying by the Professor of Metallurgy at the Michigan College of Mines. 2500 w. Eng & Min Jour—July 28, 1904. No. 64163.

Australasia.

Australasian Gold Yield. Statistics of gold production of Australia and New Zealand for the first half of 1904, with comment. Tables. 800 w. Aust Min Stand—July 14, 1904. No. 64684 B.

Boundary District.

Notes on Mining and Smelting in the Boundary District, B. C. Frederick Keefer. Read before the Can. Min. Inst. Notes on the development of the system for mining low-grade ores, particularly as regards the quarrying and handling of ores, and of features connected with the smelting operations. Plate. 1000 w. Can Min Rev—July 31, 1904. No. 64189 B.

British Columbia.

Poplar Creek and Other Camps in the Lardeau District. Prof. R. W. Brock. On the development, geology, structure, deposits, and ores of this district. Gold, silver and other metals are found. 5500 w. B C Min Rec—Aug., 1904. No. 64338 B.

The Nickel Plate Mine and Other Promising Claims at Camp Hedley, Similkameen. George E. Winkler. An illustrated account of progress made in this valley in exploration and working of mines. Gold and other metals of value are found. 3000 w. B C Min Rec—Aug., 1904. No. 64337 B.

California.

The North Star Mines. An illustrated article giving information of the equipment and improvements of these gold mines near Grass Valley, Cal. 1800 w. Min & Sci Pr—Aug. 20, 1904. No. 64710.

Chlorination.

The Chlorination Practice in the Cripple Creek District. G. E. Wolcott. Description of the operations carried on at the Economic Mill, Victor, Colo. 1000 w. Min Rept—Aug. 11, 1904. No. 64687.

Cyanidation.

Present Practice of Cyanidation in the Black Hills. William Magenau. Tables giving details of the practice at various ore mills in South Dakota, both wet crushing and dry crushing, with descriptions and illustrations. Serial. 2 parts. 5000 w. Eng & Min Jour—Aug. 11 and 18, 1904. No. 64387 C.

Cyaniding Tailings at the Golden Jubilee Mine, in Trinity Co., Cal. W. W. Merriam. Description of gold ore treatment at a plant having a capacity of 25 tons a day. 3000 w. Cal Jour of Tech—May, 1904. No. 64641 C.

Idaho.

In Boise Basin, Idaho. Illustrated description of gold dredging, hydraulic mining, and of gold mines in this district. 1500 w. Eng & Min Jour—Aug. 25, 1904. No. 64617.

Laboratory Appliances.

A New Electric Furnace and Various Other Electric Heating Appliances for Laboratory Use. H. N. Morse and J. C. W. Frazer. Review of an article in the *Am. Chem. Jour.* Description with illustrations and reports of experimental investigations. 2500 w. Min Rept—Aug. 25, 1904. No. 64709.

Mexico.

The Guanajuato Mining District. Carl Henrich. An illustrated historical account of these silver mines, which have the largest output in the world. 3000 w. Min Mag—July, 1904. Serial. 1st part. No. 64186 C.

The Method Used in Working the Silver-Lead Mines of Santa Eulalia, Chihuahua, Mexico. Edward G. Cahill. Description of deep mining below abandoned upper workings, with illustrations of crystal formation in limestone caves, 2200 w. Cal Jour of Tech—May, 1904. No. 64638 C.

New Zealand.

Milling and Treatment of Auriferous Ores in New Zealand. H. A. Gordon. Abstract from paper in Trans. of the Australasian Inst. of Mining Engrs. 5000 w. N Z Mines Rec—June 16, 1904. No. 64685 B.

Rhodesia.

Mining Potentialities of the Zambesi Valley. Theo. F. Van Wagenen. The geography, mining laws, mineral wealth, etc., of Rhodesia, South Africa, with illustrations. Min & Sci Pr—Aug. 6, 1904. No. 64689.

Sampling.

Sampling Ore Shipments. W. J. Adams. Description of standard sampling methods used at ore-treatment works, and reasons for discrepancies between their assays and

We supply copies of these articles. See page 158.

those of the mine owners. 2000 w. Min & Sci Pr—Aug. 6, 1904. No. 64690.

Sludges.

Recovery of Bullion from Zinc-Box Sludge. E. H. Taylor. From the Report of the Chamber of Mines, W. A. Notes on the economical uses of fluxes in the smelting of zinc-box sludges. 2000 w. Min & Sci Pr—July 30, 1904. Serial. 1st part. No. 64275.

Stamp Mills.

Stamp-Mill Practice in South Africa. F. C. Roberts. Illustrated account of gold ore-crushing methods in the Transvaal. 2400 w. Eng & Min Jour—Aug. 25, 1904. No. 64621.

Valuation.

Investigation and Valuation of Gold Mining Properties (Untersuchung und Wertberechnung von Goldbergwerken). S. Michaelis. A very complete account of a systematic method of investigating a gold mining property with a view of obtaining an accurate estimate of its value. Four articles. 7000 w. Oesterr Zeitschr f Berg u Hüttenwesen—July 16, 23, 30, Aug. 6, 1904. No. 64438 each D.

IRON AND STEEL.

Armor Plate.

The Manufacture of Armor Plate (La Fabrication des Plaques de Blindage). A. Bizot. An illustrated description of the Chaussade mills at Guerigny, France, where the armor plate for the French navy is made. 2000 w. 1 plate. Génie Civil—July 23, 1904. No. 64423 D.

Blast Furnaces.

Blast Furnaces in the Ural. J. Bicheroux. Abstract from a paper in the *Revue Universelle des Mines*. Describes prevailing conditions, the smelting plants, ores, etc. 1300 w. Eng & Min Jour—Aug. 4, 1904. No. 64256.

Classification.

The Classification of Iron and Steel. Albert Sauveur. Read before the Am. Soc. of Test. Mat. Gives some classifications proposed, with opinions and comments. 3300 w. Ir & Steel Mag—Aug., 1904. No. 64264 D.

Duluth.

See Mining and Metallurgy, Coal and Coke.

Gas Washer.

See Mechanical Engineering, Internal-Combustion Motors.

Iron Works.

See Mechanical Engineering, Machine Works and Foundries.

Limonite Ores.

Chemical Characteristics of Limonite (Brown Hematite) Iron Ores. F. Lynwood Garrison. Discussion, with analytical tables, of ores in the Paleozoic rocks of the Appalachian system. 1600 w. Eng & Min Jour—Aug. 18, 1904. No. 64392.

Phase Rule.

The Application of the Phase Rule to Mixtures of Iron and Carbon (Ueber die Anwendung der Phasenlehre auf die Gemische von Eisen und Kohlenstoff). Dr. Bakhuis Roozeboom. With diagram, showing the temperatures and carbon content corresponding to the various iron-carbon alloys. 1000 w. Zeitschr f Elektrochemie—July 22, 1904. No. 64454 F.

Shafts.

See Mechanical Engineering, Materials.

Steel Plant.

See Mechanical Engineering, Machine Works and Foundries.

See also Mechanical Engineering, Materials of Construction.

Stove.

The Hartman-Kennedy Fire-Brick Stove. John M. Hartman and John S. Kennedy. Illustrated description of three hot-blast stoves and equalizer for the blast-furnace plant of the Muscanetcang Iron Works, Stanhope, N. J. 500 w. Ir Age—Aug. 18, 1904. No. 64602.

Uintah.

The Iron Ores of the Uintah Mountains. A. W. Warwick. Description of deposits in the northeastern part of Utah. 1200 w. Min Rept—Aug. 18, 1904. No. 64688.

MINING.

Australia.

Mining Conditions and Progress in Western Australia. W. Burrell. Discusses wages and costs of ore treatment in Kalgoorlie. Ills. 1200 w. Mines & Min—Aug., 1904. No. 64304 C.

Boring.

Dover Colliery. An illustrated account of a system of percussive boring on an enormous scale, lining with complete rings of tubbing—the Kind-Chaudron system. 2500 w. Engr, Lond—Aug. 19, 1904. Serial. 1st part. No. 64663 A.

Cableways.

Cableway Conveyors for Mining Service (Neuere Drahtseilbahnen für Zechenbetriebe). G. Dietrich. Illustrating numerous installations of cable conveyors, both on the surface and in underground workings, in connection with electric driving. Two articles. 6000 w. Glückauf—July 23, 30, 1904. No. 64435 each B.

Drilling.

A Contract in Cleveland. Frank Seymour. Refers to the types of hand drill used in the early days of ironstone mining, and gives an illustrated description of the power drills now used. 3500 w.

Ir & Coal Trds Rev—Aug. 19, 1904. Serial. 1st part. No. 64661 A.

Electric Power.

Electrically Driven Mining Apparatus in Germany. C. L. Durand. Illustrated description of electric plants for hoisting, haulage, etc., at coal mines near Dortmund und Zwickau, Germany. 2000 w. Elec Rev, N. Y.—Aug. 20, 1904. No. 64541.

Hoisting.

A Veteran Hoisting Engine. E. R. Woakes. Illustrated description of a large hoisting engine installed at the Pozo Ancho mine of the Linares Lead Co., Ltd., Linares, Spain, in 1851. 350 w. Eng & Min Jour—Aug. 11, 1904. No. 64386.

Hoisting Drums. H. L. Auchmuty. Discusses methods of construction and the good and bad points of both metal-grooved and wood-logged drums. Ills. 1700 w. Mines & Min—Aug., 1904. No. 64301 C.

Hoisting Equipment of a French Colliery. L. Saclier. Abstract from *Revue Universelle des Mines*. Illustrated description of the arrangements at the Arenberg mine. 1800 w. Eng & Min Jour—Aug. 4, 1904. No. 64257.

Qualifications and Duties of a Hoisting Engineer. J. T. Beard. A consideration of some of the personal and educational requirements. 2300 w. Mines & Min—Aug., 1904. No. 64302 C.

Construction and Fencing of Hoists and Teagles. W. Sydney Smith. A report recently presented to the Home Office by H. M. Inspector of Factories, on the cause and prevention of accidents with hoisting machinery. Ills. 2300 w. Mech Engr—Aug. 20, 1904. Serial. 1st part. No. 64660 A.

Incline.

The Incline of the Atpoutley Coal Company. Walter H. Finley. Illustrated description of the apparatus for handling coal in cars from a high to a low elevation. 1200 w. Mines & Min—Aug., 1904. No. 64303 C.

Italy.

The Mines and Mineral Industries of Italy. Enrico Bignami. Describing especially the lead and zinc mines of Sardinia, with numerous illustrations. 4000 w. Engineering Magazine—September, 1904. No. 64483 B.

Japanese Mining.

A Great Japanese Mining Company. Benjamin Smith Lyman. An illustrated account of the Mitsui Mining Company, which mines coal, silver and other metallic ores and sulphur; but principally coal. 2000 w. Eng & Min Jour—July 28, 1904. No. 64162.

Mercur.

Mercur Mining Methods. George H. Dern. An illustrated article describing methods of handling the ores, drilling, timbering and blasting, giving some figures regarding costs of mining. 2800 w. Mines & Min—Aug., 1904. No. 64297 C.

Metalliferous Ores.

The Geographic Distribution of Metalliferous Ores Within the United States. Frederick Leslie Ransome. Facts concerning the distribution of the most important metals. 4000 w. Min Mag—July, 1904. No. 64184 C.

Mexico.

The Past and Present of the Mines of Mexico. G. C. Cunningham. A general account of the successful mining operations which have been conducted in Mexico, with information as to the methods of operation. 3000 w. Engineering Magazine—September, 1904. No. 64481 B.

Mine Explosion.

The Mine Explosion at Johnstown. M. G. Moore. A statement of the facts relating to the explosion of fire damp in the rolling mill mine of the Cambria Steel Co., July 10, 1902. 6000 w. Jour Fr Inst—Aug., 1904. No. 64356 D.

Mining.

Mining Past and Future. John A. Church. Reviews the history of the progress in mining copper, silver, gold, etc., in the United States, with comments on the future outlook. Ills. 2200 w. Min Mag—July, 1904. No. 64183 C.

Mining Laws.

Mining Laws of Mexico. Gives the most important sections of the mining law, which is considered very just, especially to foreigners. 9500 w. U S Cons Repts—June, 1904. No. 64293 D.

Power.

Transmission of Power. R. W. Chapman. Read before the Aust. Inst. of Min. Engrs. The present article discusses compressed air as a means of transmitting power from the surface to the workings. 2700 w. Aust Min Stand—July 7, 1904. Serial. 1st part. No. 64308 B.

Prospecting.

Sizing Up Prospects. Prof. Arthur Lakes. Remarks on the misleading assays of samples, and on things which should be regarded as indications as to value. 1800 w. Mines & Min—Aug., 1904. No. 64299 C.

Rand Water.

Water in the Witwatersand Mines. T. Lane Carter. Account of pumping acid water from the Transvaal gold mines, with diagram. 1500 w. Eng & Min Jour—Aug. 11, 1904. No. 64390.

We supply copies of these articles. See page 158.

Rock Crusher.

A Sectional Rock Crusher for Mining Work. Description, with illustrations of details of ore crusher weighing 7300 lbs., the heaviest parts only 300 lbs. 600 w. Eng News—Aug. 18, 1904. No. 64368.

Ropes.

Notes from the Westphalia Rope-Testing Station (Mitteilungen aus der Seilprüfungsstation der Westfälischen Berggewerkschaftskasse). H. Speer. With data and results of tests of a number of mine hoisting ropes. 2000 w. Glückauf—July 16, 1904. No. 64434 B.

Timbering.

Square-Set Practice at Bingham, Utah. Louis S. Cates. Illustrated description of timbering methods in copper mines with large bodies of low-grade ore. 2200 w. Eng & Min Jour—Aug. 25, 1904. No. 64619.

MISCELLANY.

Diamonds.

The Premier Diamond Mine. T. Lane Carter. General account of a large diamond mine in successful operation, 21 miles east of Pretoria, Transvaal. 2000 w. Eng & Min Jour—Aug. 25, 1904. No. 64623.

Diamonds in New South Wales. Llewellyn Parker. Description, with figures, of an occurrence of diamonds at Oakey Creek, near Copeton, whose source is a dike. 300 w. Eng & Min Jour—Aug. 25, 1904. No. 64622.

Magnesite.

Magnesite in California. Charles G. Yale. Brief description of deposits at Red Mountain and Porterville, and account of operating company. 800 w. Eng & Min Jour—Aug. 25, 1904. No. 64615.

Mercury.

The Metallurgy of Mercury. Dr. J. Ohly. General review. 1500 w. Min Rept—Aug. 11, 1904. No. 64686.

Nickel.

The Metallurgy of Nickel and Cobalt. Dr. J. Ohly. Concerning the applications, deposits, mode of treatment, &c. 2500 w. Min Rept—Aug. 4, 1904. No. 64305.

Petroleum.

Notes Regarding California Petroleum. Paul W. Prutzman. Paper before the Pacific Coast Gas Assoc., giving an account of production, refining, distillation and commercial products of California petroleum, with sketch map and diagrams. 7500 w. Jour of Elec—Aug., 1904. No. 64563 C.

Oil Fields and Petroleum Industry of Russia. Reports decrease in production, methods of operating, refining, transportation facilities, &c. 4300 w. U S Cons Repts—June, 1904. No. 64292 D.

Russian Petroleum. Prof. Edmond O'Neill. General account of the Baku fields and oil industry. 1200 w. Cal Jour of Tech—May, 1904. No. 64637 C.

The Mounds of the Southern Oil Fields. Lee Hager. Describes the geological structure and the conclusions reached, giving information of interest. Ills. 2200 w. Eng & Min Jour—July 28, 1904. Serial. 1st part. No. 64161.

Tin.

Tin Deposits of the York Region, Alaska. A. J. Collier. Abstract from Bulletin 229, U. S. Geol. Survey, describing the tin district on the Seward Peninsula. Serial. Part I. 1000 w. Min & Sci Pr—Aug. 13, 1904. No. 64692.

Tin Discoveries in the Bushveld. Account, taken from the *African Review*, of discoveries of rich veins of tin ore near Pretoria, Transvaal. 1000 w. Jour Soc of Arts—Aug. 5, 1904. No. 64569.

Tin Ore in North Carolina. Description, with illustrations and map of tin mines in North and South Carolina. 1000 w. Mining Wld—Aug. 20, 1904. No. 64683.

Tungsten.

Notes on Tungsten Deposits in Arizona. Forbes Rickard. Description, with illustrations, of veins and placers containing tungsten, in the Little Dragoon Mountains, and methods of working them. 3400 w. Eng & Min Jour—Aug. 18, 1904. No. 64394.

Zinc.

Notes on the British Columbia Zinc Problem. Alfred C. Garde. Read before the Can. Min. Inst. An explanation of the present situation in British Columbia, discussing the best methods for treating the extensive bodies of zinc-blende. 2500 w. Can Min Rev—July 31, 1904. No. 64188 B.

The Volumetric Determination of Zinc. Reviews the paper of W. George Waring in the *Jour. of the Am. Chem. Soc.*, giving extracts. 1200 w. Eng & Min Jour—July 28, 1904. No. 64160.

The Zinc Resources of British Columbia. A. C. Garde. Extracted from the *Lead and Zinc News*. Information showing that the zinc ores are worth mining for their zinc values. 2400 w. Can Min Rev—July 31, 1904. No. 64190 B.

Zinc Analysis.

The Determination of Lead, Iron, Lime, Sulphur, Cadmium and Copper in Commercial Zinc Ores. W. Geo. Waring. Description of analytical methods. 3000 w. Eng & Min Jour—Aug. 25, 1904. No. 64618.

We supply copies of these articles. See page 158.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Accidents.

Train Accidents in the United States in July. Detailed record. 2400 w. R R Gaz—Vol. 27, No. 10. No. 64383.

Clearance System.

Advantages of a Railway Clearance System. J. W. Midgeley. Review of attempts to establish a clearance system for cars and accounts; clearing yards the desideratum at crowded terminals. 3000 w. Ry & Engng Rev—Aug. 13, 1904. No. 64696.

Disinfection.

The Disinfection of Cattle Cars (Die Wirksame Desinfektion der Viehwagen). Adolf Freund. Showing the necessity of an effective disinfection of cars in which cattle have been carried, and advocating the use of chloride of lime. 4000 w. Gesundheits-Ingenieur—July 20, 1904. No. 64418 B.

Feeder Lines.

The Use of Motor Cars as Public Conveyances Acting as Feeders to Railways. A. Campiglio. Deals with steam cars and petrol cars, and their ability to meet such service, giving reports of applications, with costs. 4 tables. 8600 w. Bul Int Ry Cong—July, 1904. No. 64318 E.

Freight Handling.

How to Handle Freight Safely. R. C. Richards. Extracts from an address by the general claim agent of the Chicago & North Western R. R. to the agents of that company, giving much practical advice. Serial. 1st Part. 2500 w. R R Gaz—Vol. XXXVII., No. 11. No. 64629.

Railway Telephones.

The Telephone System of the Prussian-Hessian Railways (Der Streckenfernsprecher der Preussisch-Hessischen Eisenbahnen). Arthur Wilke. An illustrated description of the use of a telephone line system for the regulation and operation of a railway system. 2500 w. Glasers' Annalen—July 15, 1904. No. 64409 D.

MOTIVE POWER AND EQUIPMENT.

Cars.

Note on Increased Tonnage of Open Wagons and Increased Speed in Loading and Unloading Them. Mr. Schwabe, in *Zeitung des Vereins.* A discussion of the advantages, considering the subject in relation to the Prussian State Railway. 5 tables. 3200 w. Bul Int Ry Cong—July, 1904. No. 64319 E.

Note on the New 40-Ton Car of the Northern Railway of France (Note à Propos du Nouveau Wagon de 40 Tonnes de la Compagnie du Nord). Felix Sartiaux. A discussion of the advantages and disadvantages of large cars, showing the large gain from their use. 6000 w. Rev Gen des Chem de Fer—Aug. 1904. No. 64461 G.

100,000-lb. Coke Cars for the Chicago, Lake Shore & Eastern. Illustrated description of steel cars, built of commercial shapes, without continuous center sills. 700 w. R R Gaz—Vol. XXXVII., No. 10. No. 64382.

Car Wheels.

A Review of the Cast-Iron Wheel Situation. C. W. Gennet, Jr. Discussion of failures of wheels and improvements in form. 2000 w. R R Gaz—Vol. XXXVII., No. 9. No. 64381.

Couplers.

Automatic Couplers. William F. Pettigrew. Report to be presented at the session of the International Railway Congress, to be held in Washington, May, 1905. Ills. 3500 w. Ry Age—July 29, 1904. No. 64214.

On the Question of Automatic Couplers (Subject VII. for Discussion at the Seventh Session of the Railway Congress). William F. Pettigrew. Considers the advantages and disadvantages, the improvements effected in their construction, and their use with other couplers. For England. Ills. 5700 w. Bul Int Ry Cong—July, 1904. No. 64316 E.

Electrification.

Application of Electricity to Steam Roads. Prof. L. S. Randolph. Paper before the Richmond Ry. Club. Discusses the advantages and disadvantages of the electrical system. 4500 w. Ry & Engng Rev—July 30, 1904. No. 64216.

Explosion.

A Locomotive Explosion (Une Explosion de Locomotive). R. Bonnin. A fully illustrated account and discussion of the serious explosion of the boiler of a locomotive at the St. Lazare station in Paris. 2500 w. Revue Technique—July 25, 1904. No. 64424 D.

Front Ends.

Front Ends and Steam. F. P. Roesch. Some particulars about front end conditions and the writer's views as to their design, &c. 1200 w. Loc Engng—Aug., 1904. No. 64208 C.

High Speed.

High-Speed Steam-Locomotive Tests in Germany. An account of the recent ex-

We supply copies of these articles. See page 158.

periments made, describing the engines and giving the results. 1500 w. U S Cons Repts—June, 1904. No. 64296 D.

Locomotives.

A 4-4-2 High-Speed Machine on the Pennsylvania Lines. Illustrated description of an Atlantic type of engine for fast passenger work. 1100 w. Loc Engng—Aug., 1904. No. 64205 C.

Eight-Coupled Locomotive Built in Queensland. Illustrated description of 3 ft. 6 in. gauge freight locomotive built at Government workshops, Queensland, Australia. 500 w. Engr, Lond—Aug. 5, 1904. No. 64520 A.

German High-Speed Three-Cylinder Compound Locomotive. Illustrated description of locomotive and tender exhibited by Henschel & Son, of Cassel, at the St. Louis Fair. 1800 w. Ry & Engng Rev—Aug. 13, 1904. No. 64695.

Heavy Six-Wheel Switcher for the New York Central R. R. Illustrated description of locomotive built at the Schenectady Locomotive Works. 700 w. Ry & Eng Rev—Aug. 20, 1904. No. 64722.

New Locomotives for the Mexican Central Ry. Illustrates a 2-6-0 type as an example of the engines designed for this road. Description and dimensions. 800 w. Ry & Engng Rev—July 30, 1904. No. 64215.

The Development of the Compound Locomotive in England. W. E. Dalby. The first portion of a review of the growth of the compounding of locomotives on British railways, with many illustrations of important engines. 3500 w. Engineering Magazine—September, 1904. No. 64484 B.

The Engine Arrangement in Four-Cylinder Compounds. Gives a sketch indicating the arrangement in four types, with brief description of each design. 250 w. Ry Age—July 29, 1904. No. 64212.

The Mallet Articulated Locomotive at the St. Louis Exhibition. H. W. Hanbury. Well-illustrated description of large compound locomotive built by the American Locomotive Co. 1 Plate. 2000 w. Engng—Aug. 5, 1904. No. 64513 A.

Locomotive Tanks.

Fittings Around the Tank. James Kennedy. A criticism of the present methods, and statement of the evils they cause. 1000 w. Loc Engng—Aug., 1904. No. 64211 C.

Shoes.

Method of Laying Off Shoes and Wedges. John W. Percy. Drawing and explanation of method used in laying off shoes and wedges on offset frames where the rocker box and hanger on the fire box are in the way of the trams. 800 w. Loc Engng—Aug., 1904. No. 64206 C.

Transfer Table.

Electric Transfer Table (Chariot Transbordeur Electrique). M. Pouchucq. Illustrated description of transfer tables of the Western Railway of France, arranged to travel upon curves and upon straight tracks. 2500 w. Rev Gen des Chem de Fer—Aug., 1904. No. 64462 G.

Valve Gear.

The Walschaert Valve Gear. Editorial giving general description. 1000 w. Ry Age—Aug. 12, 1904. No. 64698.

PERMANENT WAY AND BUILDINGS.

Ecuador.

The Guayaquil & Quita Ry., in Ecuador, South America. John A. Harman. Illustrated description of the construction of a railway from the seacoast to the Andean plateau through very difficult country. 3500 w. 1 plate. Eng News—Aug. 11, 1904. No. 64361.

Egypt.

Egyptian Railway Administration Works at Cairo. An illustrated detailed description of the works and their equipment. 5300 w. Ry & Engng Rev—Aug. 6, 1904. No. 64325.

Freight House.

Concrete Block Freight House for the Chicago Great Western. Illustrated description of building at East Waterloo, Iowa. 400 w. R R Gaz—Vol. XXXVII., No. 11. No. 64630.

Panama.

Maintainance of Way on the Panama Railroad. Track, water tank with posts imbedded in concrete, and other features, with profile of road and illustrations. 1200 w. Ry Age—Aug. 19, 1904. No. 64720.

Roundhouse.

New Roundhouse and Coal Chutes for the Chicago Great Western Ry., at Oelwein, Iowa. Illustrated description. 1200 w. Ry & Engng Rev—Aug. 20, 1904. No. 64721.

San Pedro & Salt Lake.

Permanent Way and Structures of the San Pedro, Los Angeles & Salt Lake. General description, with illustrations of stations, viaduct, etc. 600 w. R R Gaz—Vol. XXXVII., No. 9. No. 64379.

Shop Plant.

Power Generation and Distribution at a Large Railroad Shop. Illustrated description of the plant of the large locomotive shop at East Moline, Ill. 2400 w. Elec Wld & Engr—July 30, 1904. No. 64235.

The Power Plant of the Rock Island Railway Shops at East Moline. Illustrates and describes a plant which includes steam, pneumatic, hydraulic and electric

We supply copies of these articles. See page 158.

machinery. 3500 w. Eng Rec—July 30, 1904. No. 64181.

Shops.

Power Equipment of the New Shops of the Mexican Central Railway Company, Limited, Aguascalientes, Mexico. R. M. Henderson. Well illustrated account of buildings, power plant, electric distribution, etc. Serial. 2 parts. 7000 w. Elec Rev, N Y—Aug. 13 and 20, 1904. No. 64539 C.

Power Plant of the Mexican Central Shops at Aguascalientes. Illustrated description of steam and electric plant for railway shop. Serial. 1st part. 3500 w. Eng Rec—Aug. 20, 1904. No. 64506.

The Mexican Central Shops at Aguascalientes. Illustrated description of the shops and their equipment. 2500 w. R R Gaz—Aug. 5, 1904. No. 64290.

Shop Equipment. William S. Cozad. A criticism of the average railroad shop facilities. 2400 w. Am Engr & R R Jour—Aug. 1904. No. 64200 C.

Ideal Blacksmith Shop and Equipment for General Railroad Work. A. W. McCaslin. Extract of paper before National Assoc. of Blacksmiths. 1200 w. R R Gaz—Vol. XXXVII., No. 11. No. 64628.

See also Street and Electric Railways.

Signals.

Automatic Block Signals. Ralph Scott. Discusses the relative inherent advantages of each standard system. Ills. 2500 w. Am Elect'n—Aug., 1904. No. 64175.

Electric Interlocking. A letter from L. Weissenbruch, of the Belgian State Rys., referring to a former article of his on the Antwerp interlocking plant, with diagrams and editorial comment. 3000 w. Ry Age—Aug. 12, 1904. No. 64697.

Stations.

New Station of the Lackawanna at Roseville Avenue, Newark. Illustrates and describes a new station made necessary by the change of grade. 600 w. R R Gaz—July 29, 1904. No. 64165.

New Stations on the St. Louis & San Francisco. Gives plans and illustrated descriptions of some of the designs. 1200 w. R R Gaz—Vol. XXXVII., No. 8. No. 64288.

Terminals.

Substructure for the New Union Station, Washington. Illustrated description of the substructure of an important terminal, which consists entirely of concrete piers and walls. 2800 w. Eng Rec—Aug. 6, 1904. Serial. 1st part. No. 64276.

Passenger Terminal at Long Island City. General description, with illustrations of yard and tracks and Westinghouse electro-pneumatic interlocking switch and signal system. 1 plate. 1300 w. R R Gaz—Vol. XXXVII., No. 9. No. 64378.

Track.

The Pennsylvania Railroad's Track Construction for City Streets. Illustrated description of track construction in Philadelphia, with girder rails weighing 141 lbs. per yard. 300 w. Eng Rec—Aug. 20, 1904. No. 64507.

Trestles.

See Civil Engineering, Bridges.

Tunnels.

See Civil Engineering, Construction.

Turnouts.

A Problem in Locating Turnouts. C. M. Kurtz. Illustrated description of practical method for laying out railroad tracks, having regard to the angle of the frog at the turnout. 500 w. Eng News—Aug. 25, 1904. No. 64612.

Tyrol.

The Mendel Railway (Die Mendelbahn). K. Jordan. An illustrated description of the combined adhesion and cable railway over the Mendel Pass in the Austrian Tyrol. Two articles. 7000 w. Zeitschr d Oesterr Ing u Arch Ver—July 29, Aug. 5, 1904. No. 64416 each D.

TRAFFIC.

Freight Rates.

On the Question of Slow Freight Rates (Subject XIII. for Discussion at the Seventh Session of the Railway Congress). Harry Smart, for England. Explains the general principles with description of different systems of rating slow freight goods. 3300 w. Bul Int Ry Cong—July, 1904. No. 64317 E.

Fruit Traffic.

The Tropical Fruit Traffic. Describes the methods, shipments and railroad facilities for caring for the fruit, especially bananas. 1800 w. Ills. R R Gaz—Vol. XXXVII., No. 8. No. 64289.

Pooling.

Pooling Locomotives—Double and Multiple Crews. Camille Boell. Report to be presented at the Int. Ry. Cong. in Washington May, 1905. Report based on information from 26 roads, with conclusions. 3300 w. Ry Age—Aug. 5, 1904. No. 64324.

MISCELLANY.

Fire Protection.

Railway Property and Fire Protection. An illustrated article discussing principally fire-extinguishing machinery. 3500 w. Transport—July 15, 1904. No. 64167 A.

Missouri Pacific.

The Growth of the Missouri Pacific. Reviews the history of this road and its development. 2000 w. R R Gaz—July 29, 1904. Serial. 1st part. No. 64164.

We supply copies of these articles. See page 158.

Mountain Railway.

The Mount Pilatus Railway, Switzerland. Emile Guarini. An illustrated account of this road and the combined locomotive and car which is used to climb to an altitude of 6,800 feet, on a track 15,150 feet in length. 2000 w. Sci Am—Aug. 13, 1904. No. 64355.

Siam.

Siamese Railway Tenders. Gives copies of specifications and conditions for tender on rolling stock and accessories for the royal Siamese State railways. 2800 w. U S Cons Reports—June, 1904. No. 64294 D.

Statistics.

The Railways of the World (Die Eisenbahnen der Erde). A tabulated statement of the railways of the world by countries, showing the mileage, growth since 1898, and relation to area and population. 2000 w. Stahl u Eisen—July 15, 1904. No. 64432 D.

Switzerland.

The Nationalization of Swiss Railways. A. Achard. Reviews the circumstances which made it seem desirable for the State to acquire the principal lines of railway, the measures by which the way was prepared, the method in which the work of purchase was carried out, and the results thus far. 7000 w. Trac & Trans—Aug., 1904. Serial. 1st part. No. 64347 E.

Uganda.

The Uganda Railroad. Review of the final report of the committee appointed to supervise the building of this road from Mombasa, on the east coast of Africa, 584 miles to Victoria Nyanza, giving general account of the construction and the present traffic returns. 1200 w. R R Gaz—Vol. XXXVII., No. 11. No. 64624.

STREET AND ELECTRIC RAILWAYS

STREET AND ELECTRIC RAILWAYS.

Barrow-in-Furness.

The Tramways in Barrow-in-Furness. Illustrated description of track cars, and other features of an English electric railway. 1600 w. Tram & Ry Wld—Aug. 11, 1904. No. 64573 B.

Buenos Aires.

Notes on Street Railway Systems of Buenos Aires. Guillemo A. Puente. Statistics and illustrated description of power station and other features. 1600 w. St Ry Rev—Aug. 20. 1904. No. 64571 C.

Canal Traction.

A Review of the Present State of Mechanical Canal Traction. F. H. Davies. Considers the advantages and disadvantages of the system tried, concluding in favor of electrical tractors. 4000 w. Elec Engr, Lond—Aug. 19, 1904. No. 64670 A.

Cars.

A Remarkable Combination Semi-Convertible and Convertible Car for City Service. Illustrated description of a car for the Montreal Street Railway. 700 w. St Ry Jour—Aug. 6, 1904. No. 64272 C.

Body Framing of Modern Interurban Cars. Edward C. Boynton. Illustrated description. 700 w. St Ry Jour—Aug. 13, 1904. No. 64566 C.

Electric Car with Six-Wheel Trucks and Motors of 800 Horse Power. Illustrated description of large car built by the John Stephenson Co. 500 w. Eng News—Aug. 25, 1904. No. 64611.

Extensive Improvements in Elevated Car Equipments—Brooklyn Rapid Transit Company. Illustrated description of new platforms, brake rigging, electric equipment, fireproofing, and other features. Serial. 2 parts. 8000 w. St Ry Jour—Aug. 13 and 20, 1904. No. 64564 each C.

Side-Door Coaches for World's Fair Service. Charles Alma Byers. Brief description with illustrations. 500 w. Sci Am—Aug. 27, 1904. No. 64650.

The New Type of Elevated Car Without Platforms, Boston Elevated Railway Company. Illustrated description. 1000 w. St. Ry Jour—Aug 6, 1904. No. 64271 C.

Compulsory Traffic.

Tramways and Compulsory Running Powers. Thomas Upton. Discusses the decision of the British Parliament to grant to a public company compulsory running powers over a portion of a certain municipal tramway. 3000 w. Elec Rev, Lond—July 29, 1904. No. 64313 A.

Darlington.

Electric Traction at Darlington. Illustrated description of track, power-house and other features of an English electric road. 2000 w. Tram & Ry Wld—Aug. 11, 1904. No. 64574 B.

Derby.

The Derby Electric Tramways and Electricity Supply. Illustrated description of large electric power house and railway system in England. 1800 w. Elec Engr—Aug. 12, 1904. No. 64556 A.

Dubuque, Iowa.

A Large New Steam Turbine Power Plant Installation for Dubuque, Iowa. Description and plans of a proposed power plant planned for the exclusive use of

We supply copies of these articles. See page 158.

steam turbines. 5500 w. St Ry Jour—Aug. 6, 1904. No. 64269 C.

Electrification.

Application of Electricity to Steam Roads. L. S. Randolph. Paper before the Richmond Railroad Club, containing a general discussion of the subject. 4000 w. Elec Rev, N Y—Aug. 13, 1904. No. 64540.

Electrification of Steam Railways in England. Philip Dawson. General discussion. 2000 w. Ry Age—Aug. 19, 1904. No. 64719.

Glasgow.

The Glasgow Tramways. A review of the operation, traffic, finances, etc., of 70 miles of double-track surface electric railway, serving about 1,000,000 population. 3000 w. Engr, Lond—Aug. 12, 1904. No. 64522 A.

Incline.

The Palermo-Monreale, Italy, Incline System. C. L. Durand. Illustrates and describes a line operated by electricity having some interesting features. 1700 w. Elec Rev, N Y—Aug 6, 1904. No. 64274.

Instruction Car.

Instruction Car on the New York Subway. Illustrated description of car and method of instructing 3000 motormen in anticipation of the opening of the rapid transit road. 1500 w. St Ry Jour—Aug. 20, 1904. No. 64568 C.

Lackawanna & Wyoming.

The Lackawanna & Wyoming Valley Railroad. D. A. Willey. Illustrated description of an interesting electric road between Scranton and Wilkesbarre, which represents the most advanced type of third rail electric traction yet completed in the United States. 2000 w. Elec Rev, N Y—Aug. 27, 1904. No. 64708.

Leicester.

Leicester Corporation Electric Tramways. E. G. Mawbey. Detailed description of an English electric railway. The first part is devoted chiefly to the power station. Illustrations and map. Serial. Part I. 4000 w. Public Works—Aug. 15, 1904. No. 64645 D.

Light Railways.

The Application of Electric Traction to Light Railways. H. Luithlen. Abstract of a report to be presented at the Vienna meeting of the International Tramways and Light Railways Association. Considers the advantages of electric traction over steam for light railway service. 2000 w. St Ry Jour—Aug. 27, 1904. No. 64706 C.

London.

Metropolitan Electric Tramways. General description, with outline map, of electric surface railways in the northern part of London. 1600 w. Tram & Ry Wld—Aug. 11, 1904. No. 64575 B.

Multiple-Unit.

Sprague's Multiple Unit System of Electric Traction. Report of the Committee on Science and the Arts on the invention of Frank J. Sprague. 1200 w. Jour Fr Inst—Aug., 1904. No. 64360 D.

The Westinghouse Unit-Switch System of Multiple-Unit Train Control. Illustrates and describes the method of controlling the driving power as exemplified in this system. 2500 w. Elec Engr, Lond—July 29, 1904. No. 64309 A.

Municipal Ownership.

City-Owned Street Cars. Walter C. Hamm. On the municipalization of the street car system of Hull, England. How it was accomplished, the mode of operation, and the success. 2200 w. Eng Rec—Aug. 6, 1904. No. 64286.

Newcastle.

Descriptive Account of the Newcastle Corporation Tramways System. A. E. Le Rossignol. Read before the Incor. Assn. of Munic. & Co. Engrs. Ills. 2000 w. Elec Engr, Lond—July 22, 1904. No. 64222 A.

New York Central.

The New York Central Plans in the Center of New York. An account, based on an interview with H. E. Andrews, of plans for consolidating electric roads and electrifying portions of steam roads. 1800 w. St Ry Jour—Aug. 13, 1904. No. 64567 C.

Northampton.

Northampton Corporation Electric Tramways. General illustrated description of power house, track and other features of an English electric railway. 2000 w. Elec Engr, Lond—Aug. 5, 1904. No. 64554 A.

Ohio.

The Springfield, Troy & Piqua Railway Co. Illustrated description of the line, power house and substation equipments and rolling stock of a recently opened Ohio interurban electric railway. 3000 w. St. Ry Rev—Aug. 20, 1904. No. 64572 C.

Operation.

The Operative Costs of Tramways and the Builder's Guarantees (Die Unterhaltungs kosten bei strassenbahnen und die Garantie der Baufirma). A. Hecker. A discussion of the elements of traffic, distance, frequency of trips, etc., upon which estimates of operating costs are based. 2500 w. Elektrotech Zeitschr—July 28, 1904. No. 64450 B.

Paris-Orleans.

The New Locomotives and Motor Cars for the Paris-Orleans Railway Co. M. Vingoe. Description, with illustration of

We supply copies of these articles. See page 158.

track. 900 w. Elect'n, Lond—Aug. 12, 1904. No. 64547 A.

Raworth System.

Raworth's Traction Patents. Account of successful demonstration of Raworth's system of automatic regenerative control for electric cars, the motors being compound wound, the series coils being used for emergency purposes and the shunt for normal. Diagrams and tables. 2000 w. Elec Rev, Lond—Aug. 12, 1904. No. 64552 A.

Shops.

New Car House and Shops for the Twin City Rapid Transit Company. Illustrated description of new buildings at St. Paul, Minn., in process of construction. 1400 w. St. Ry Jour—Aug. 27, 1904. No. 64705 C.

Single-Phase.

Compensated Motor Railway Equipment of the General Electric Company. Illustrated description of electric motors and other equipment of a new single-phase road, the Ballston division of the Schenectady railway. 1600 w. Elec Wld & Engr—Aug. 27, 1904. No. 64727.

Compensated Single-Phase Motor of the General Electric Company. Illustrated description with report of the recent test on the Ballston Division of the Schenectady Railway Company. 2500 w. St Ry Jour—Aug. 27, 1904. No. 64704 C.

The First American Single-Phase Railway in Commercial Operation; The General Electric System on the Ballston Line of the Schenectady Ry. Co. Illustrated description of line, cars and apparatus. Also, editorial. 4500 w. Eng News—Aug. 25, 1904. Also R R Gaz—Vol. XXXVII., No. 11. No. 64610.

The Operation of the Single-Phase Motor on the Niederschöneweide-Spindlersfeld Line (Der Betrieb mit Einphasigem Wechselstrom auf der Strecke Niederschöneweide-Spindlersfeld). H. von Glinski. Detailed description of the motor, made by the Union Elektrizitäts-Gesellschaft, and diagrams showing the results of tests. 3000 w. Glasers Annalen—August 1, 1904. No. 64411 D.

Statistics.

Statistics of Electric Railways in Germany (Statistik der Elektrischen Bahnen in Deutschland). The usual yearly tabulated report, showing very fully the growth of electric railways in Germany, with editorial comments. 15000 w. Elektrotech Zeitschr—July 21, 1904. No. 64448 B.

Storage Batteries.

The Storage Battery as Applied to Electric Railways. W. E. Winship. Considers their installations in central and substations, showing their utility. 2200 w. Jour Fr Inst—Aug., 1904. No. 64358 D.

Subway.

The New York Rapid-Transit Subway. H. C. Fyfe. A fully illustrated description of the subway just completed in New York City, describing the location, construction and details of operation. 5000 w. Engineering Magazine—September, 1904. No. 64479 B.

Third-Rail.

Changes in the Baltimore and Ohio Locomotive Pick-Up Device. Illustrated description of an improved pick-up compressor installed on the cab. 1500 w. St Ry Jour—July 30, 1904. No. 64203 C.

Extension of the Third-Rail System of the Paris-Orleans Railway. An illustrated account of this work, with explanation of its aim. 3500 w. St Ry Jour—Aug. 6, 1904. No. 64268 C.

Inverted Third Rail Upon the Brooklyn Bridge. An illustrated description of an innovation in electric third-rail arrangement. 1300 w. St Ry Jour—July 30, 1904. No. 64202 C.

Third-Rail Heating.

A Third-Rail Electric Heating System. William Greenow, Jr. Description of a method for keeping the third rail free from ice by heating it with an auxiliary electric wire placed under the rail head, but insulated from the rail. 1000 w. R R Gaz—Vol. XXXVII., No. 10. No. 64384.

Traffic.

Analysis of Traffic and Methods of Development. Henry W. Brooks, Jr. Suggestions as to methods of stimulating traffic. 4000 w. St Ry Jour—July 30, 1904. No. 64204 C.

Tramcars.

Tramcar Design and Construction. Elmer E. Cook and T. C. Elder. On the importance of first-class construction, discussing present day types. Ills. 3200 w. Trac & Trans—Aug., 1904. Serial. 1st part. No. 64346 E.

Underground.

Chicago's Underground Freight Railroad. Illustrated detailed description of this tunnel, with statement of its purpose, methods of construction, motive power, equipment, method of handling trains, &c. 5000 w. Ir Age—Aug. 4, 1904. No. 64238.

Valve Handles.

Automatic Valve Handle Returning Device. Illustrated description of a device invented by A. Gottschalk, for automatically returning the handle of the motorman's brake valve after the maximum train line pressure of 70 lbs. has been accumulated. 600 w. Loc Engng—Aug., 1904. No. 64209 C.

We supply copies of these articles. See page 158.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

Serial publications are indexed on the appearance of the first installment.

SPECIAL NOTICE.—To avoid the inconvenience of letter-writing and small remittances, especially from foreign countries, and to cheapen the cost of articles to those who order frequently, we sell coupons at the following prices:—20 cts. each or twelve for $2.00, thirty-three for $5, and one hundred for $15.

Each coupon will be received by us in payment for any 20-cent article catalogued in the Index. For articles of a higher price, one of these coupons will be received for each 20 cents; thus, a 40-cent article will require two coupons; a 60-cent article, three coupons; and so on. The use of these coupons is strongly commended to our readers. They not only reduce the cost of articles 25 per cent. (from 20c. to 15c.), but they need only a trial to demonstrate their very great convenience—especially to engineers in foreign countries, or away from libraries and technical club facilities.

Write for a sample coupon—free to any part of the world.

CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
American Shipbuilder. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brick Builder. *m.* Boston.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Cassier's Magazine. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.

Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Magazine. *m.* New York.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Page's Magazine. *m.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.
Public Works. *m.* London.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Klijk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.

CURRENT RECORD OF NEW BOOKS

NOTE—Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post Office Orders, home and foreign, should be made payable to THE ENGINEERING MAGAZINE.

Conversion Tables.

Ready Reference Tables. Volume I. Conversion Factors of Every Unit or Measure in Use. By Carl Hering, M. E. Size, 7 by 4 in.; pp. xviii, 196. Price, $2.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Although there have been innumerable tables and compilations of units and measures and of their equivalent values in different systems, the present volume, which is the first of several having data conveniently arranged for ready reference, contains the most complete and accurate collection of measures and their interconversion factors that has probably ever been brought together. These conversion factors have all been especially recalculated, under the direction of the author, from the exact legal values, and from the most standard and authoritative values where no legal ones exist. The fundamental values were obtained from the U. S. National Bureau of Standards and similar bodies, by whose officials they were checked after the pages had been electrotyped. All the conversion factors were calculated from the same set of fundamental values, so that they are all consistent with each other and form a single, interconvertible, uniform system. Seven-place logarithms of nearly all the conversion factors are given, as well as approximate values of the principal ones. In the introductory part there is a discussion of the interrelation of units, the distinction between units and quantities, and similar questions, and there is a table of physical quantities, giving the derivation, symbols, dimensional formula, and other data concerning each. There is a most complete and up-to-date collection of the electric, magnetic and photometric units, with explanations of them all, and tables showing their interrelations. Compound units and their conversion factors are given, as well as thermometer scales, monetary tables, and a complete index. Altogether, this work appears to be practically exhaustive, and one has a refreshing feeling of security in dealing with figures which are founded on such reliable authorities, and are so accurate and consistent.

Corporations.

Moody's Manual of Corporation Securities. Fifth Annual Number, 1904. John Moody, Editor; C. L. F. Bridge and Louis W. Holschuh, Associate Editors. Size, 9 by 6 in.; pp. 2372. Price, cloth, $10; flexible leather, $12. New York and Chicago: Moody Publishing Co. London: Effingham Wilson.

There is so much loose talk and writing about the "trusts" and great companies which exercise such a tremendous influence in our affairs and touch the lives of the people at every point, that it is refreshing to get away from generalities, which are usually anything but glittering, and learn some reliable facts concerning these corporations. The present volume affords such an opportunity, for it is crammed with statistics of the corporations and financial institutions of America, so well arranged and so carefully indexed, that any information sought may be found at once. This edition of Moody's Manual is an advance on all previous ones. Special efforts have been made to elaborate the sections devoted to steam railroads and other public service corporations; in the lists of railroad bonds the complete and uniform descriptions of mortgages are supplemented by maps of some of the railroad systems. The industrial section is very comprehensive and full of interest. In all divisions of the work each corporation has statistics given concerning the property owned and controlled by it, its capitalization and bonded debt, dividends paid, financial condition and earnings, officers, managers and directors, location of plants and offices, and so on. The contents are arranged in eight sections, containing, respectively: Membership lists of all the stock exchanges of the United States and Canada; statistics of American and foreign government and State securities; steam railroad corporations of the United States, Canada and Mexico; gas, water, electric light and electric railway corporations in these countries; telephone, telegraph and cable corporations; industrial and miscellaneous corporations; mining and oil corporations; banks, trust companies and other financial institutions.